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**NOVA SCOTIA BARITE STUDY
DEPOSITS, DEVELOPMENT, MARKETS**

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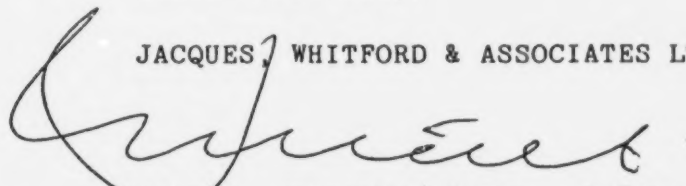
Dear Mr. Collings:

RE: N.S. Barite Study OSQ85-00109

I enclose herewith our final draft of the report on Nova Scotia Barite Deposits. We are pleased to have conducted this work on behalf of Canmet and look forward to similar assignments in future.

Yours very truly,

JACQUES, WHITFORD & ASSOCIATES LTD.



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JAA/hmw
Enclosure

Consulting Engineers

MAY 30 1986

NOVA SCOTIA BARITE STUDY - DEPOSITS, DEVELOPMENT, MARKETS

BY

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HALIFAX, N.S.

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EXECUTIVE SUMMARY

This report summarizes the characteristics, occurrences, beneficiation, and marketing of barite with particular reference to the Atlantic region, and describes six Nova Scotia barite deposits selected for their proven or potential value. Information for this report has been drawn from numerous papers, reports, files and maps, both published and unpublished, and from field visits to three of the deposits.

The physical properties and geologic occurrence of barite make this mineral reasonably easy to mine and mill. Barite concentrations in the form of tabular veins, residual accumulations and bedded deposits are the most common, and occur almost everywhere in the world. Both underground and open-pit methods have been successfully used to mine barite deposits of all sizes. Most of the milling equipment used to separate and concentrate barite ores are those which take advantage of barite's relatively high specific gravity (4.5). Milling operations using dense media, flotation, cyclones, shaking tables or jigs have all been used successfully.

Markets for barite are both diverse and world-wide because this mineral has several natural characteristics which make it unique for a wide range of uses. Because of its extraordinary density, over 80% of all barite mined is used for drilling muds in the petroleum industry. For the same reason it is also used as a weighting agent in heavy concretes, in counter-weights and dead-weights, and for ballast in container ships. Barite's opacity to X-rays makes it appropriate as an aggregate in concrete walls and floors around X-ray equipment, and possibly, too, as a coating for thread in aprons which would be lighter than the lead ones usually worn for radiation protection. Barium sulphate is also used in diagnostic medicine where it is taken orally by patients so that internal organs can be examined for pathological changes. Similarly, barite might be added to plastic toys so that they would be visible if accidentally swallowed. Nearly 10% of all barite consumption goes to make a wide range of barium compounds used as fillers, extenders and whiteners in paints, pharmaceutical products, specialty papers, rubber-based products, and various chemical compounds. It may also be worthwhile to use barium-coated fabric for

curtains and solid barriers to sound-proof noisy environments such as those associated with airports, factories and heavy equipment.

Total world production of barite amounts to about 7 or 8 million tonnes annually. The United States, China and the Soviet Union are the major producers; yet small countries like Ireland, Morocco, Peru and Thailand produce significant quantities. Canada usually supplies only about 1% of world production. The major consumers are the United States, the Soviet Union, West Germany and Mexico, with the smaller countries mentioned above supplying them with imported barite. Recent fluctuations in barite consumption amounting to as much as 1 million tonnes annually have been caused by sudden changes in well-drilling activity.

Barite occurrences in Nova Scotia are numerous and examples of most types of deposits are known. Six deposits have been selected as those best representing the geological and historical characteristics of barite occurrences in this province. Three deposits from mainland Nova Scotia (Brookfield, Walton, and Bass River) and three from Cape Breton Island (Lake Ainslie, Scotsville, and Pine Brook) are described with respect to their geological relationships, mining and milling operations, and production and reserves. All have produced barite ore in the past and all have the potential for further shipments.

Résumé exécutif

Ce rapport souligne les propriétés, les gisements, l'enrichissement, et la commercialisation du barytine en faisant mention spéciale à la région de l'Atlantique. De plus, le rapport décrit les six gisements de barytine sélectionnés d'après leur valeur démontrée ou potentielle. Ce rapport recueille l'information obtenue dans divers articles, rapports, dossiers et cartes, publiés et non-publiés, ainsi qu'à travers des études du terrain menées sur trois des six gisements.

Les propriétés physiques et les événements géologiques du barytine facilitent l'exploitation minière et le broyage de ce minéral. Les gisements de barytine sous les formes plus communes de filons tabulaires, gîtes résiduels, et gisements stratifiés se trouvent à travers le monde. On a exploité les gisements de barytine dans les mines à ciel ouvert et souterraines, et ce, avec succès. De plus, il a été observé que l'appareillage de broyage le plus utilisé pour la séparation et la concentration du minéral de barytine est celui qui prend avantage de la forte densité du barytine (4.5). Les opérations de broyage couronnées de succès sont celles ayant employé les méthodes suivantes: les agents denses, la flotation, les cyclones, les tables à secousses, ou les cribles hydrauliques.

Le marché du barytine possède des dimensions diverses et mondiales grâce aux propriétés abondantes de ce minéral, un minéral unique et utile à une variété d'emplois. Sa densité exceptionnelle, par exemple, rend le barytine très utile comme boue de forage dans l'industrie du pétrole (on emploie 80 pourcent du barytine de cette façon). Sa densité est également la raison pour laquelle le barytine est employé comme agent de pesage dans le béton lourd, les contre-poids, et en tant que ballast dans les porte-conteneurs.

L'opacité du barytine est également important dans l'emploi de ce minéral comme agrégat dans les murs et planchers de béton, l'équipement de radiographie et possiblement en tant que couche de veinules dans les tabliers servant à protection contre la radiographie, rendant ces tabliers beaucoup plus légers que ceux recouverts de veinules de plomb. On compte bien d'autres usages, tels que le sulphate de barytine employé en médecine pour le diagnostique de certains changements pathologiques aux organes internes et même dans la fabrication de jouets afin de discerner leur présence quand avalé accidentellement par les enfants.

Près de 10 pourcent du barytine est utilisé à fabriquer des composés de baryum de tout genre, tels que les enduits, les charges, et les blancs dans les peintures, les produits pharmaceutiques, le papier à lettres, les produits en caoutchouc, et une variété de composés chimiques. On pourrait de même prendre avantage des tissus recouverts de baryum pour fabriquer des rideaux et des barrières qui insonoriseraient nos plus bruyants milieux comme nos aéroports et nos fabriques.

La production de barytine mondiale s'approche de 7 à 8 millions de tonnes par année. Les principaux producteurs dans ce marché sont les États-Unies, la Chine et l'Union Soviétique, mais les plus petits pays comme l'Irlande, le Maroc, le Pérou et la Thaïlande y fournissent des quantités considérables. Les gros consommateurs de ce produit sont les États-Unies, l'Union Soviétique, l'Allemagne de l'ouest et le Mexique, les petits pays précités fournissant ces derniers avec du barytine importé. Les variations récentes de la consommation du barytine à environ 1 tonne chaque année, sont le résultat des changements aux opérations de forage de puits.

Les gisements de barytine sont nombreux en Nouvelle-Écosse et des spécimens de presque tous les genres de ce gîte ont déjà été étudiés. On a sélectionné six gîtes typiques des propriétés géologiques et historiques du barytine dans cette province: trois gîtes d'entre eux proviennent de la Nouvelle-Écosse continentale, notamment à Brookfield, à Walton et à Bass River; et les trois autres sont situés à l'Île du Cape Breton et en particulier, au lac Ainslie, à Scotsville et à Pine Brook. Ces gisements sont décrits d'après leur rapport géologique, les opérations de broyage et d'exploitation minière, la production et les réserves. Tous ces gisements ont produit du minéral de barytine dans le passé, et tous possède le potentiel d'en produire davantage pour les cargaisons à l'avenir.

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I. INTRODUCTION

At one time Nova Scotia was a significant producer of barite for use as drill muds in the petroleum industry. The material was widely used in countries of the Atlantic rim where exploration for oil and gas was a growing industry. Most of this production came from the Walton Mine operated by Magcobar Minerals Division of Dresser Industries Inc. However, with the closure of this mine in the mid 1970's, Nova Scotia was no longer a source of barite for these markets. The increase in petroleum exploration over the last decade, particularly on Canada's own east coast, has made the situation even more acute. Nova Scotia has been hard pressed to supply even small quantities of mud-grade barite for these operations.

Record-high unit prices for barite landed at the dockside in Halifax, N.S. and in St. John's, Nfld., prompted a wave of entrepreneurs to try to secure barite stone to meet that market. Government agencies also developed programs to assist local producers to generate Nova Scotia stone suitable for the offshore application. In the haste of the development, only one producer was successful in producing stone in any significant quantity. Other operations failed to meet either the quality or the quantity requirements for the contracts. As a result, a very limited quantity of Nova Scotia stone was available for the offshore market. Much of the requirements were therefore met by importing large quantities from Morocco and Ireland. This eventually saw the depression of the prices from a record of \$500 per ton down to a current price of less than \$100 per ton.

In light of these difficulties, it seemed worthwhile to evaluate some selected Nova Scotia barite deposits with respect to their value in current and future markets, particularly as they apply to anticipated offshore developments both on Canada's east coast and elsewhere in the world, and to examine alternative uses for barite and barite products. It is in this context that the Federal government, through its agent, CANMET, issued a contract titled "Nova Scotia Barite Study - Deposits, Developments and Markets". The terms of reference are in Appendix 1.

The contract was awarded in early July of 1985 and work proceeded immediately to identify the sources of information available on barite and its various markets, and to identify deposits that would be considered worthy of study. The major structure of the report and the specific deposits to be discussed in detail were agreed to during the course of early consultation with the Scientific Authority. The work reported herein was conducted under the overall direction of Mr. John Amirault, M.Eng., P.Eng. Vice President of Mining, Jacques, Whitford and Associates assisted by Mr. Baruck Wile, B.Sc., B.Eng. and Mr. Greg MacNeill, B.Eng. staff engineers with Jacques, Whitford and Associates Limited. Technical review of the manuscript and final editing was performed by Warren Ervine, Ph.D., P.Eng., GeoTech Surveys Ltd., a specialist consultant to the firm on geological matters.

The information presented herein is derived largely from available data from previous reports and workers. We attempted to contact all persons involved in barite production and sales in Nova Scotia. Site examinations were made at Brookfield, Pine Brook and Scotsville where workings were exposed and personnel were available to consult. Operations at Bass River, Lake Ainslie and Walton were dormant.

This report has the following organization. The two sections following the introduction deal with the geology, mining and beneficiation of barite in order to provide a world-wide basis for evaluating Nova Scotia deposits and their extraction. Section IV describes the marketing of barite and barite-derived products with special reference to this mineral's unique characteristics. Section V describes the type and genetic characteristics of Nova Scotia barite deposits in general and six selected deposits in detail. Section VI is a discussion of the potential for Nova Scotia barite and recommendations on areas where research and development would be worthwhile. The References used in this study are listed alphabetically. An Appendix is included to provide a source of technical information, specifications, and typical flow sheets for milling barite. The Addendum is a condensation of a report on a visit to the Scotsville deposit by W. J. D. Stone, P.Eng., of Magstone Development Inc.

The writers of this report gratefully acknowledge the willing assistance provided by the various barite producers and consumers within the province of Nova Scotia and, as well, the government agencies that gave so freely of their time and information. We would like specifically to mention Messrs. J. Fowler and P. Hannan, P.Eng., at the Nova Scotia Department of Mines and Energy, Mr. D. Graham with Dresser Macgobar, Mr. Patterson with Scotsville Minerals Corporation, Mr. Prostak, P.Eng., and Mr. Reina with Nystone Chemical Corporation, Mr. Barrett of Novex and Mr. Richardson of Scotia Barite Limited.

II. GEOLOGY OF BARITE

A. Mineralogy of Barite

Barite, also known as "barytes", "cawk", "tiff" and "heavy spar", is the most common mineral containing barium and occurs almost everywhere in the world. It is natural barium sulphate, BaSO_4 , containing 58.8% Ba and, together with witherite, BaCO_3 , provides the chief commercial sources for barium. Barite is a member of the sulphate series of minerals to which also belong the isomorphous minerals celestite (SrSO_4), and anglesite (PbSO_4).

Barite crystallizes in the dipyramidal class of the orthorhombic system. Well-formed crystals are generally tabular with three cleavages. Barite in most commercial deposits occurs as concretions, nodules, rosettes, irregular masses and in laminated to massive beds of fine crystallinity. It is brittle and has a hardness of 2.5 to 3.5 and a specific gravity up to 4.5, depending on purity. The mineral is relatively insoluble in water and acids, essentially making it chemically inert.

The colour of barite is highly variable but white, gray and dark brown are those most commonly observed. Yellow, blue, red and brown are also found. Impurities such as iron oxide, graphite and carbonaceous material are responsible for the different colours. Other impurities include silica, clay and the diadochic elements Ca and Sr. Crystals may be transparent or opaque, and have a vitreous, resinous or even pearly lustre.

Barite occurs as a major mineral in veins and beds, and as gangue in veins containing minerals of Pb, Cu, Zn, Ag, Ni, Co, Mn, etc. It is often associated with one or more of stibnite, fluorite, quartz, calcite, dolomite, siderite, hematite, etc. Barite may also be found as a cement between the grains of a sandstone, as a cavity filling in amygdaloidal rocks, and as fillings and replacements of fossils.

B. Types of Deposits

Barite has been found in many geological environments involving igneous, sedimentary and metamorphic rocks. It may occur in sufficient concentrations to be considered for recovery as a primary product or as a co- or by-product. The long history of barite mining suggests that barite deposits can be classified into three main categories: vein-and-cavity-filling deposits, residual deposits, and bedded deposits.

The information contained in the following sections has been drawn liberally from summary papers by Dean et al, 1955; and by Brobst, 1958, 1970, 1973, 1975, and 1981.

1. Vein-and-Cavity-Filling Deposits

Vein-and-cavity-filling deposits are those in which barite and associated minerals occur along faults, gashes, joints, bedding planes, breccia zones, solution channels and sink structures. These deposits may occur in almost any kind of host rock and range in age from Precambrian to Tertiary.

The barite in most of the vein-and-cavity-filling deposits mined principally for barite is dense, white to gray, and commonly associated with such minerals as quartz, jasperoid, calcite, dolomite, siderite, witherite, rhodocrosite, fluorite, and various sulphide minerals (e.g. pyrite, chalcopryite, sphalerite, galena, etc.). Barite may be sufficiently abundant in many veins to be recovered as a co-product or by-product from some deposits mined principally for lead, zinc, gold, silver, fluorspar and rare earths. The grade of barite in all the deposits of this group varies widely between, and even within, deposits.

Vein-and-cavity-filling deposits commonly have sharp contacts with the wall rocks. Large-scale replacement of the wall rocks beyond the ore-controlling structures is rare. Individual veins commonly pinch and swell and range from a few centimetres to a metre or so in thickness, from several metres to hundreds of metres in length, and up to a hundred metres or so in depth. Barite that fills faulted zones has formed many mineable deposits, but are often of small extent.

Barite deposits in collapse and sink structures are common in limestones such as those in the Appalachian region and in Missouri in the United States where they are known as circle deposits. These deposits occur in roughly circular, rubble-filled collapse structures that are bell- or cone-shaped in vertical section with the apex up. Some of these deposits were rich in barite, but most of them were less than a hundred metres in diameter and fifty metres in depth.

The general characteristics of vein deposits are difficult to describe because of their great variety. In the early days of barite mining in the United States, vein deposits contributed the major part of the domestic production but, since the turn of the century, have been overshadowed by the production from residual deposits. Elsewhere in the world vein deposits were, and still are, the leading barite producers since the early days of barite mining.

2. Residual Deposits

Residual barite deposits occur in unconsolidated material formed by the weathering of pre-existing deposits. Many deposits of commercial value have been worked in a clayey residuum derived from Cambrian and Ordovician limestone and dolomite, such as those in Missouri and in many parts of the Appalachian region of the United States.

Most of the barite in residual deposits is white and translucent to opaque, and occurs as discrete platy, fibrous, mammillary, or dense, fine-grained, irregular masses, most of which range from 2 to 15 centimetres across the largest dimension. Small amounts of pyrite, sphalerite, and galena are commonly associated with some of this barite. Locally, lead and zinc may be minor by-products of the barite mining. Yellow, red, or brown ferruginous clays and some incompletely weathered fragments make up the bulk of the deposits. Chert and jasperoid are also common in many deposits.

The size and shape of residual deposits varies greatly. Some extend over several hundred hectares, but there are those which have been exploited over a limited area. The shape of residual deposits generally reflects the nature of the sources of the barite. Deposits derived from vein systems tend to be elongate and those derived from sink structures are usually circular. Some deposits in the southern Appalachian region are ribs or pillars of bedrock containing veins of barite with calcite, quartz, fluorite, pyrite, chalcoprite, sphalerite and galena protruding upwards into a residuum of as much as 50 metres of clay. In other deposits only disseminated pods or thin veinlets of barite occur in the bedrock.

The barite content of the residuum varies between and within deposits. It is usually expressed as a weight of material recovered from a standard unit volume of residuum. In practice, the grade of the material is not known for sure until the calculations are made after the barite is recovered. It is difficult to profitably work a typical residual deposit in the United States that contained less than 60 kg of barite per cubic metre (2.3%). Recent changes in product price and operations efficiency, even in the face of declining grades of ore, have made it possible for some operations to continue in

residuum containing well below the 120 kg per cubic metre considered about the minimum grade 20 years ago.

3. Bedded Deposits

Bedded deposits include those in which barite occurs as a principal mineral or cementing agent in stratiform bodies in layers of sedimentary sequences. The major commercial deposits of this type are the bedded concentrations of generally dark-gray to black, fine-grained, fetid barite. These deposits are the world's foremost producers of barite. Some of these deposits are large and single deposits generally contain millions of tons of easily beneficiated barite. Bedded deposits now being worked at Battle Mountain have made Nevada the world's premier barite producer. Other deposits of this type are also known in Arkansas, California, and Alaska in the United States; British Columbia and Yukon in Canada; and also in Mexico; West Germany; India; and South Africa. The bedded deposits are worth considerable discussion because of their economic value and the excellent potential for finding more of them in many parts of the world.

The geologic features of bedded deposits may be summarized briefly. The beds of barite range from several centimetres to 15 metres in thickness and extend a thousand metres or so in length or over several hectares. Individual beds range from thinly laminated to massive and, along with intercalated beds of dark chert and siliceous shale and siltstone, may reach a total thickness of 30 metres. Geochemical halos of increasing barium content toward the richest beds have been detected at many deposits and may extend as much as 50 m stratigraphically above and below the ore zone.

The barite grains are usually less than 0.1 mm in diameter. Barite nodules and rosettes make up a substantial part of some barite beds and a smaller part of some of the silty and shaly beds. In some deposits nodular beds appear to form envelopes around the beds containing the highest grade barite. Some of the nodules have concentric rings of barite and the rosettes have a radially bladed structure. These structures suggest that room for free growth existed during deposition. Conglomerate beds consisting of nodules and fragments of barite, chert, phosphate (apatite), and fragments of other rocks in the sequence in a fine-grained matrix of barite occur in the huge deposits of the Toquima Range, Nevada and in other deposits.

Deposits of black bedded barite are geographically scattered and most common in rocks of mid-Paleozoic age. Deposits occur in rocks of Ordovician (Nevada), Devonian (California, Nevada, British Columbia, Yukon, West Germany), Lower Carboniferous (Arkansas, Yukon), Upper Carboniferous

(Idaho) and Permian (Alaska) age. Recently, black bedded barite has been described from Archean (South Africa) and Proterozoic (India) rocks.

Many layers of ore in bedded deposits contain 50 to 95% barite. The chief impurity is fine-grained quartz whose abundance is inverse to that of barite. Small amounts of clay and pyrite are common, though carbonate minerals are rare. Trace elements include Ca and Mg (totaling 10,000 ppm), Sr (<7000 ppm), Mn and V (each <50 ppm), and Co, Cu, Ni, Y, and Zr (each <20 ppm). Up to several per cent of organic matter, sometimes smelling of H₂S, is also common in barite beds. These amounts are considerably lower than those found in vein deposits.

Some black bedded barite deposits are associated with stratiform massive sulphide bodies that contain base and precious metals with locally abundant barite gauge. Some of the largest examples of this type are now being evaluated in the Selwyn Basin, Yukon. Other deposits consist mostly of white to clear barite which cements the clastic grains of sandstones and conglomerates.

C. Genesis of Barite Deposits

Hydrothermal solutions are probably the ultimate source of the barium found in all deposits. The barite and associated minerals of the vein-and-cavity-filling deposits are indeed typical of suites precipitated from hydrothermal solutions and most geologists agree that many, if not most, vein deposits had such an origin. The temperature of these solutions covers a wide range, from the highest for those solutions closely associated with magmatic sources and volcanic vents to the lowest for those deposits farthest from the source of the mineralizing solutions. Many deposits in the mid-continent and Eastern United States have been termed telethermal as an indication that the mineralizing solutions travelled far from their source and were, therefore, somewhat cooler than the more usual epithermal solutions considered the source of many vein deposits in the western United States.

Submarine volcanic emanations may be the source of some bedded barite and massive sulphide deposits that formed at the same time as the enclosing rocks, such as those in Germany. The volcanic rock materials incorporated into sedimentary sequences are considered the source of barium and the metals that may form mineral deposits during the diagenesis of the host rocks.

Evidence has been accumulating recently to suggest that some bedded barite, and possibly even some vein deposits, might form from connate brines and groundwaters. If the brines were to seep out of the ground (e.g. from shelf

sediments) and mix with sea water, barium sulphate would form and precipitate to the sea floor to form beds of barite. Alternatively, the barium ions might be adsorbed on clays settling through the sea water where they would combine with the ubiquitous sulphate ions to form barium sulphate. These barium-rich clay beds could later give rise to nodular barite.

The barium of most bedded deposits has probably been recycled from primary igneous formations by mechanical and chemical processes and transported to the sea with hydrolyzates or adsorbed on clays. Any barium reaching the sea will likely form barite by combining with the abundant marine sulphate under commonly prevailing conditions.

Modern studies involving crystallography and mineralogy suggest that barium might be trapped in the precipitation of marine carbonate. Barium ions will fit into the lattice of aragonite, considered by many the primary precipitate of calcium carbonate. Because the barium cation will not fit into the lattice of calcite or dolomite, it will be expelled from the lattice when aragonite converts to either of these minerals. If any sulphate occurs in the pore fluids, the barium might be fixed as barite in the veinlets or nodules so common in the carbonate rocks. Should the pore fluid be chloride-rich, rather than sulphate-rich, the expelled barium might be converted to the very soluble chloride, in which case the barium could be held in solution to be precipitated later, either in place or elsewhere, as barite when sulphate ions become available.

Connate waters may play an important role in the redistribution of barium from the carbonate and shale or clay environment.

Another little-understood aspect of the generation of barite deposits in sedimentary environments is the virtually unevaluated role of organisms, especially bacteria, in the movement and redistribution of elements such as barium in the sedimentary environment under conditions of low temperature and pressure. In a study of the organic material from the huge black bedded deposits of Nevada, it was concluded that anoxic conditions prevailed in the areas in which the deposits accumulated. Three possible sedimentary environments were proposed in which these beds of barite might have developed. The organic geochemical processes in the formation of mineral deposits in general is a difficult, but an inviting field of research that will undoubtedly yield information which will eventually lead to other major deposits.

III. MINING AND MILLING OF BARITE

A. Mining Methods

Barite is mined by underground or open-pit methods or, in a few places, by both procedures. Limitations of the method chosen are dictated by the characteristics of the deposit, such as the spatial relationships of size, shape and attitude, and the relative physical or mechanical properties of the barite, gangue and host rock. For any given mineral deposit, however, there is generally an optimum mining method with a well-defined cost per tonne of material mined.

Most of the older barite mines were underground operations and in many parts of the world this is still the dominant method, especially where the deposit is small, or is of the vein-and-cavity-filling type. Some underground techniques include blast-hole stoping and modified block caving where the deposit is a vein structure or a body of variable dimensions, and room and pillar where the deposit is bedded.

Open-pit mining has increasingly become the more popular and economic choice of mining method, especially for deposits that are large and/or close to surface. Often bulldozers and other heavy earth- or rock-moving equipment can rip the open exposures or face of the ore. Frequently there is a need for at least some blasting of the overburden or host rock. The broken material can be easily loaded by front-end loaders directly onto dump trucks holding up to 30 tonnes each and hauled to storage areas where the ore can be stockpiled for crushing. Hydraulic back-hoes are particularly useful for irregular orebodies because they can selectively remove the barite ore from the waste rock. This reduces the dilution factor and provides a high-grade feed to the mill.

In Nova Scotia, barite mining has been carried on both by underground and by open pit methods. In recent years, however, the emphasis has changed from high-tonnage operations which require a large capital outlay and a high-capacity mill to match, to the consideration of orebodies which can operate on a small scale, with selective extraction methods, and/or on a seasonal basis. This approach is particularly suited to

Nova Scotia-based demand for stone to feed locally operated mills either small and/or portable. The techniques used in individual cases are more appropriately described in the sections dealing with the geology of the deposits.

B. Milling Techniques

The milling of an ore mineral like barite is influenced greatly by its physical and mechanical properties, by the relative proportion of associated minerals (whether valuable or not) and, of course, the grade of the ore (barite) delivered from the mine. The high specific gravity and the relatively low hardness of barite determine the selection of the principal pieces of milling equipment to be used because most equipment is designed to function according to specific separation principles. The efficiency by which this equipment operates often depends largely on the size and shape of the barite grains themselves. The nature and proportions of the associated minerals and their potential for profitable recovery govern the sequence of the equipment through which the ore passes. The grade of barite brought to the mill not only determines the necessity of an early up-grading phase, but the probability of returning a profit on the entire operation.

The main techniques used to separate barite from its associated minerals depend on two important operating principles.

1. Those particles which are relatively larger and/or more dense respond more readily to the effects of gravity.
2. Those particles which have relatively larger cross-sectional areas respond more readily to moving fluids.

The following sections describe the techniques embodying the first or both principles used to separate a dense mineral like barite by gravity and/or size (Table 1). Some of the techniques depend on differences in density only (e.g., dense media separation); some depend on differences in density being enhanced by adhering bubbles (e.g., flotation cells) or by centrifugal forces (e.g., cyclones); and others depend on a combination of differences in density and differences in cross-sectional areas (e.g., sluices, shaking tables, jigs).

There are two general limitations to the use of these kinds of equipment for separating barite. First, gravity methods of separation become cumbersome and inefficient when the average particle is so minute that its surface friction dominates its movement through the

TABLE 1

Principles Involved in Separation Techniques

Separated by differences in:	Technique:
Gravity alone	Dense Media Separation
Gravity, enhanced by adhering bubbles	Flotation
Gravity, enhanced by centrifugal forces. . .	Cyclones
Gravity & Size: in horizontally moving water.	Sluices, Shaking Tables
in vertically moving water	Jigs

surrounding fluid. Exploitation of differences in specific gravity of particles below 150 mesh is difficult and should be avoided when alternate methods of treatment are available. Secondly, the physical properties of the associated minerals (i.e., specific gravity, hardness, grain size distribution, grain shape, etc.) must also be considered, especially if one or more of the minerals is to be recovered from a complex ore.

1. Dense Media Separation

Dense media separation consists essentially of continuously feeding a stream of crushed and washed (de-slimed) ore into a fluid or pseudo-fluid body contained in a vessel which is arranged so that both the float (light) and sink (heavy) products are continuously discharged along with the medium (Figure 1). Because the method depends wholly on differences in buoyancy between particles of different densities, the pseudo-fluid medium must have a specific gravity lying between that of the minerals to be separated. For example, a medium of 2.8-2.9 will separate barite (4.2-4.5) from most rock-forming minerals (2.7). The medium must have an internal friction or viscosity low enough to permit sufficiently high particle velocities to promote good recoveries. The medium must also be reasonably stable so that only minimal agitation is required. The most popular pseudo-fluid is formed from ferrosilicon (S.G.=6.8-7.0) which is ground to pass 65 mesh (65-75% should pass 200 mesh) and suspended in water by gentle agitation.

The process can handle a wide range of sizes, i.e., 20 cm to 65 mesh, but at least two stages are required. Coarse feed ranging from 20 cm down to 5 cm can be treated economically and efficiently in a static operation by a cone, pyramidal vessel or drum separator. The finer sizes from 5 cm down to 65 mesh are best treated in a cyclone using a dense medium where separating forces are greatly increased by use of centrifugal force.

Dense media separation as a technique for concentrating barite has been used widely throughout the world, although its operating efficiency has never reached its fullest potential. It is commonly used to up-grade ore which is relatively coarse, i.e., >0.5 cm. The process requires considerable water, which is used mainly to wash the medium particles off the ore grains. The equipment has a high capital cost but, with skilled labour, this can be offset by lower operating costs, despite above-average power demands. (A dense media separation system is shown in Appendix 2.)

Another method of separation and concentration of heavy minerals is one using cone concentrators which operate on principles similar to those for dense media separators. A stream of crushed ore is fed onto the upper apex of a large

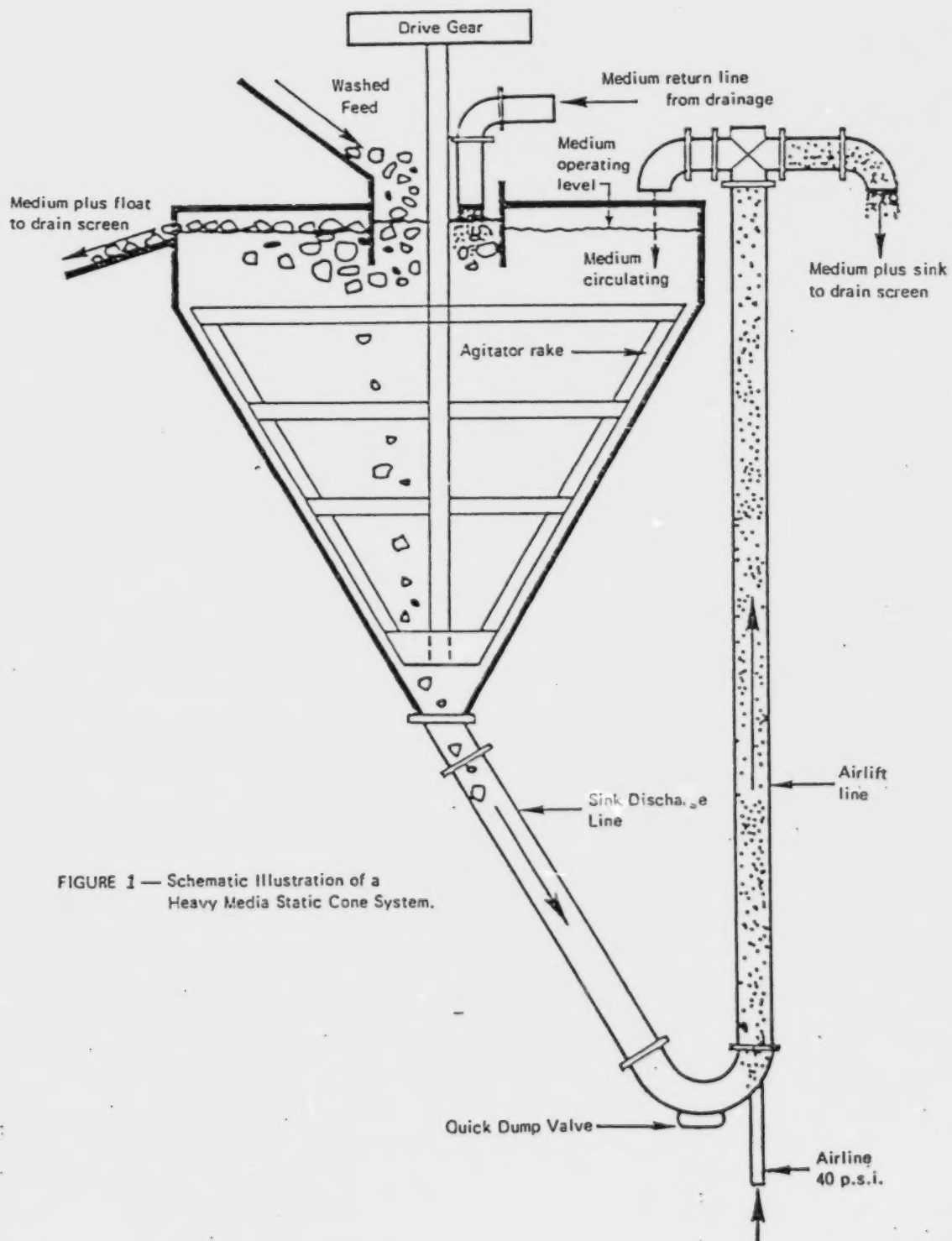


FIGURE 1 — Schematic Illustration of a Heavy Media Static Cone System.

"flat" cone. When the material reaches a point just above the outer rim of the cone, it will have sorted itself so that the heavy particles can drop through a narrow (though adjustable) slot. A series of cones ensures maximum separation. This equipment is currently being used to separate cassiterite at North America's only tin mine, Yarmouth County, N.S.

2. Flotation Cells

Minerals that cannot be liberated at a size suitable for treatment by all-gravity methods can often be treated in a flotation cell. It is chiefly practised on feeds ranging from 60 mesh to a few microns in particle size. Under the influence of appropriate chemicals, the surfaces of some mineral particles in the pulp remain attached to water (hydrophilic) while others become attached to air bubbles (aerophilic). The loaded bubbles then rise to the surface where they form an unstable froth which overflows, carrying off the mineral thus concentrated.

Many barite deposits in Nova Scotia also contain considerable fluorite and/or sphalerite, some of which may be in sufficient concentrations to be profitably recovered. Such complex ores are best treated by a series of flotation cells, with typical sequences being sphalerite-barite-fluorite and sphalerite-fluorite-barite. For example, zinc flotation (actually sphalerite or marmatite) begins with a roughing stage and then two stages of cleaning to produce a concentrate assaying approximately 60% Zn. The tailings are thickened, partly to remove the flotation reagents from the zinc circuit, and then conditioned for barite flotation.

Barite flotation consists of a roughing stage, scavenging and four stages of cleaning to produce a drilling-mud concentrate which is thickened, filtered and dried. The tailings are thickened to assist in the removal of barite flotation reagents and then conditioned and subjected to fluorite flotation. This flotation step may use roughing and scavenging with up to six stages of cleaning, depending on the grade of fluorspar product required, to produce fluorspar concentrates. These concentrates are then thickened, filtered and dried. Final tailings are pumped to the tailings dam. (See Appendix 3 for typical flow sheets.)

3. Hydrocyclones

Hydrocyclones and Humphrey spirals use gravity, enhanced by centrifugal forces, to separate barite from other minerals. The equipment operates on the principle that, when a centrifugal force is applied to a particle, its effective mass is increased which, in turn, increases its rate of fall. Thus, when a pulp is fed tangentially into a cyclone (Figure

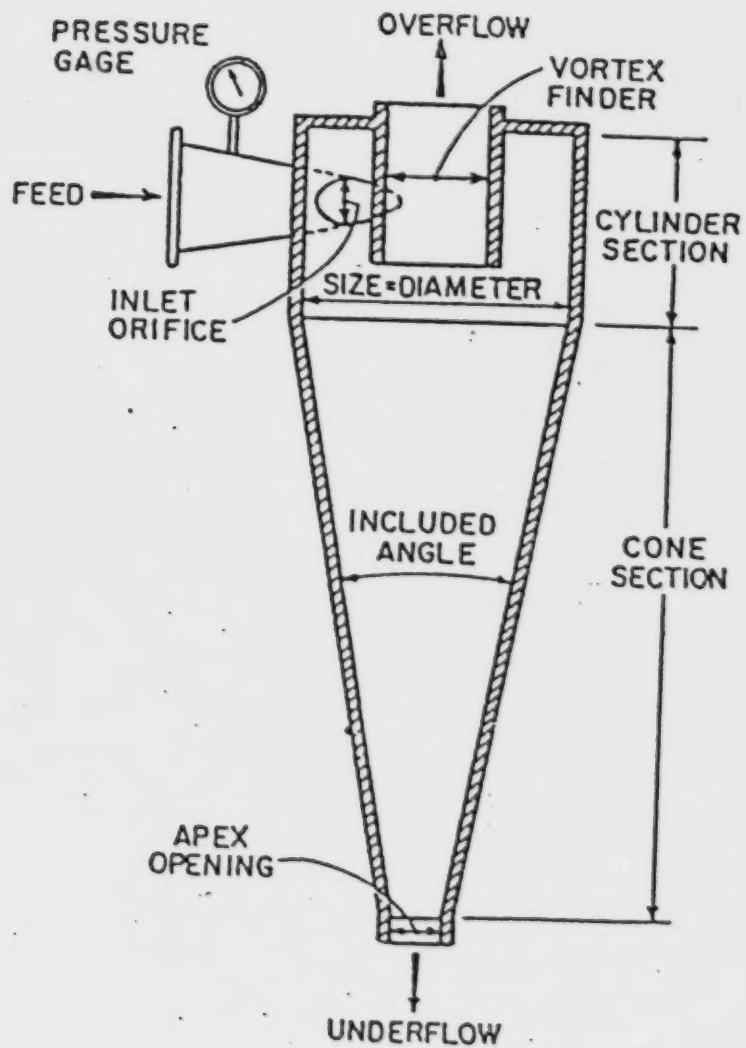


FIGURE 2: Cross-Sectional View of a Typical Hydrocyclone

2), a vortex is generated about the longitudinal axis. The accompanying centrifugal acceleration increases the settling rates of the particles, the coarser of which reach the cone's wall. Here they enter a zone of reduced pressure and flow downward to the apex, through which they are discharged. At the centre of the cyclone is a zone of low pressure and low centrifugal force which surrounds an air-filled vortex. Part of the pulp carrying the finer particles moves inward toward this vortex and reaches the gathering zone surrounding the air pocket. Here it is picked up by the vortex finder (tube) and removed through a central overflow orifice. The vortex finder is so adjusted as to project into the cylindrical section of the cyclone, so that short-circuiting of the newly arriving pulp is minimized.

Hydrocyclones are increasingly used for classifying the finer sizes, ranging from 150 to 5 microns. Some operators indicate that they are more efficient where the gangue is not much harder than the barite. Humphrey spirals are most often used where the barite and lighter minerals are well liberated. However, they are inappropriate for complex barite ores containing fluorite, galena and/or sphalerite because these minerals are invariably lost.

4. Separation by Moving Water

Moving water is the most common fluid used in separating particles of different physical properties. The methods involve the principle of particle inertia resulting from both density and size differences. It is therefore a multi-force technique involving particle size, particle shape, density, fluid resistance and inter-particle interference.

The principle has been developed in a variety of ways to produce different effects for each piece of equipment. Water moving horizontally (or nearly so) is used as a medium in sluices where it flows continuously, or on shaking (or riffle) tables where it oscillates. Similarly, water moving vertically is used in a variety of classifiers where it flows more or less continuously or in jigs where it oscillates. Some examples of these techniques are described in the following sections.

(a) Sluices Non-turbulent flowing water can be very easily adapted to separate minerals according to their densities. It is a technique which is widely evident in natural concentrations (e.g., placers) and has also been used by man in small operations since the early ages. Mineral particles caught up in a thin layer or film of water flowing over a flat, inclined surface will sort into size ranges by the differential action within the water layer. The useful characteristic is that the velocity of flow in the water layer is not the same at all depths, but rather ranges from nearly

zero at the contact between the water and the plane surface to a maximum value just below the air-water interface.

If the upper end of a sluice were fed a heterogeneous mixture of mineral particles, each particle would be influenced by a series of forces and respond according to its particular characteristics. That is, because each particle sinks in the water at a rate that is proportional to its weight, it is carried a horizontal distance which is some function of the time of its vertical fall (Figure 3). The particles are then subjected to the uneven distribution of forces present in the flowing layer of water, namely near zero velocity at the plane surface and maximum velocity at the air-water interface. The moving water presses against the cross-sectional area of the particles and rearranges them according to their respective sizes and densities to produce a downslope particle arrangement as shown in Figure 4.

1. Fine, high-density particles
2. Coarse, high-density and small, lower density particles
3. Coarse, lower density particles

It is important to note that, because the coarse, heavy and fine, light particles are found in proximity to each other, sizing the particles before treatment would yield sharper separations.

(b) Shaking Tables Shaking and riffle tables are also used for the gravity separation of material down to about 40 microns, which is much too fine to treat by jigging (see next section). If in addition to the downhill travel of the particles mentioned above, the whole plane is given a sideways movement, the horizontal displacement of the particles will vary according to the time they take to roll or slide downhill. Figure 5 shows that, although the largest light particles have moved downslope the farthest (i.e., they reached the bottom first), they have the least horizontal displacement. Conversely, while the smallest heavy particles have moved downslope the least i.e., they move more slowly, they have been displaced farthest in a horizontal direction. It is evident, then, that by accelerating the deck sideways and abruptly reversing the motion, the feed can be spread into bands according to both size and density. By collecting the various products in separate containers, a reasonable separation is made.

The efficiency of a shaking table can be improved by installing a series of ridges or riffles to the surface of the inclined plane. By setting them parallel to the direction of sideways movement and approximately normal to the direction of

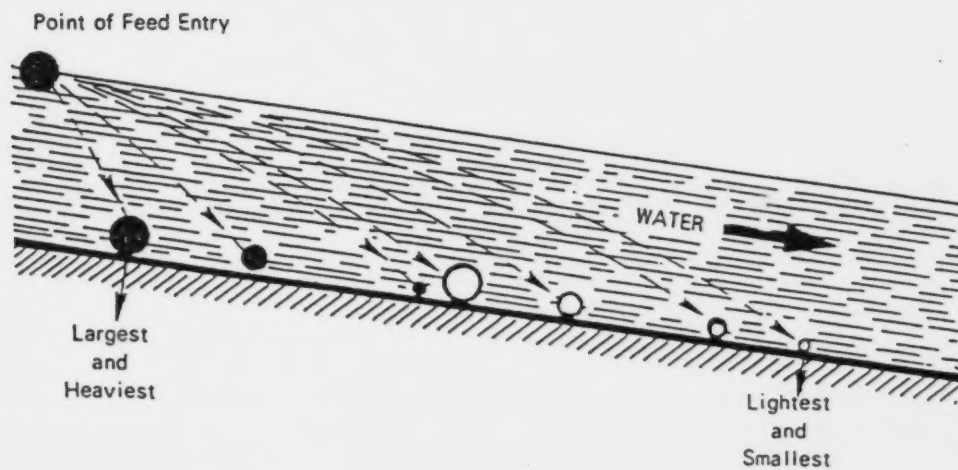


FIGURE 3: Initial Particle Movement in Flowing Water

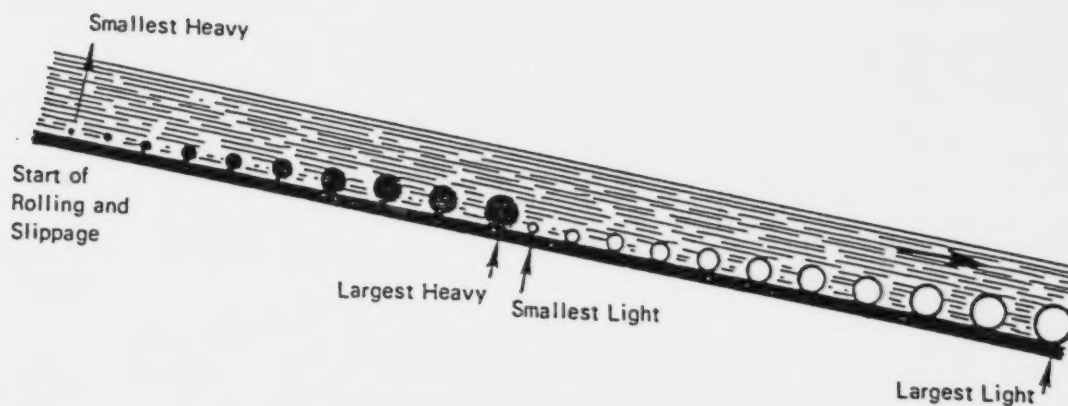


FIGURE 4: The Classifying Effect of Flowing Water on Particles of Different Sizes and Densities

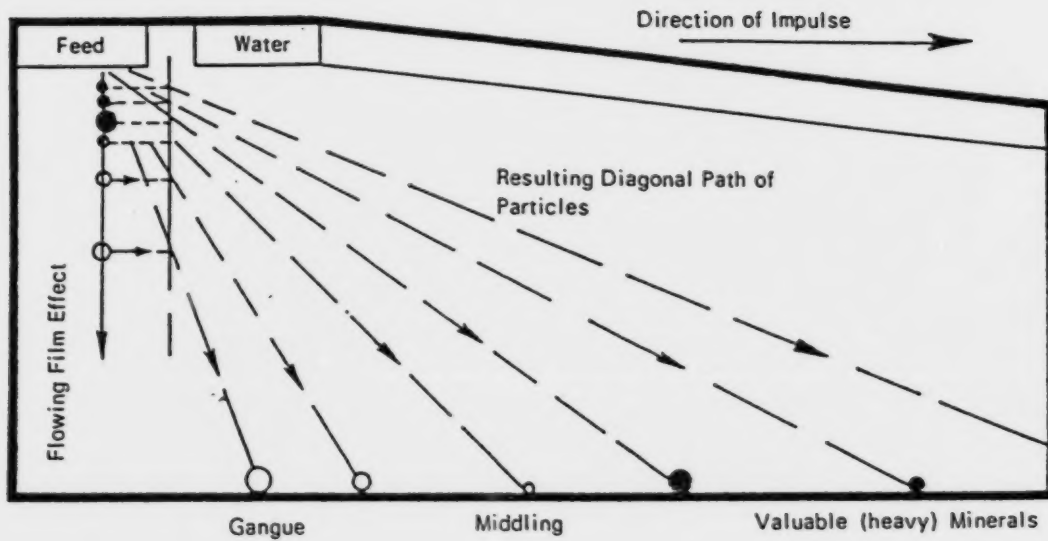


FIGURE 5: How Lateral Acceleration and Flowing Film Effects Cause Minerals to Separate on a Table

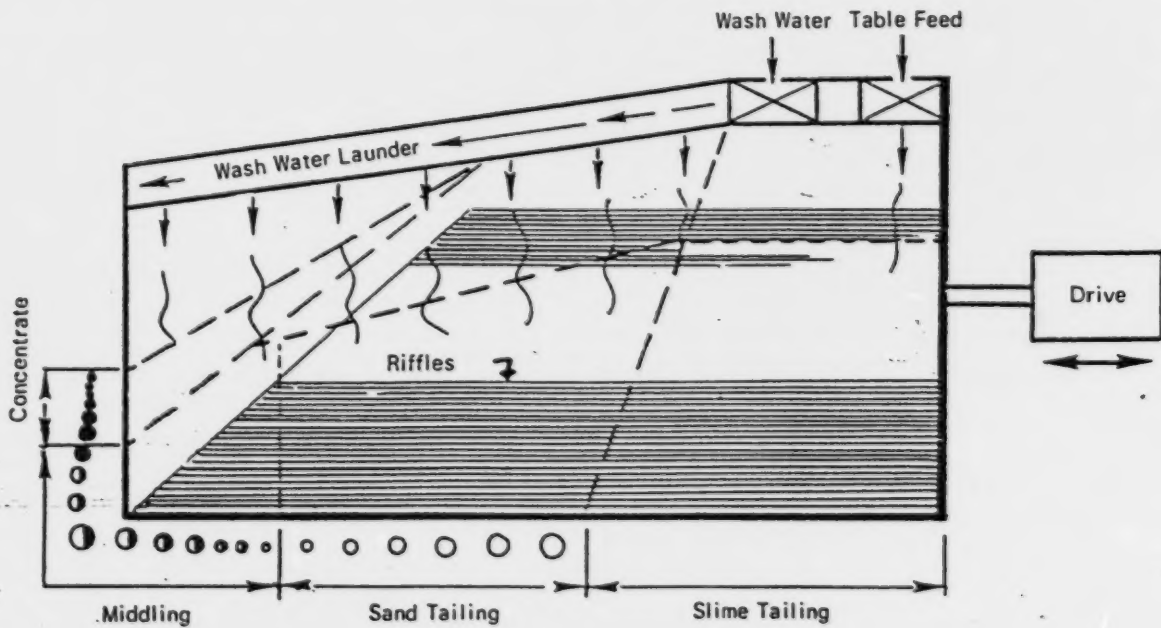


FIGURE 6: The Distribution of Separated Particles on a Riffles Table

water flow, the riffles can provide the protection behind which a stratification and vertical sorting could take place. The largest and lightest particles would rise to the top of each ridge where they would receive the maximum sluicing force of the streaming water film (Figure 6). The smallest and heaviest particles would reach the deck where they would have greater frictional contact and so be diverted farther in a sideways direction. The effect can be controlled by varying the slope of the incline and the volume of wash water.

(c) Jigs Jigging is a form of gravity concentration carried out by pulsing water through a screen on which lies a bed of crushed ore. When a mixture of sized particles of different densities is fed continuously into a box which is closed by a screen on its underside and through which water pulsates, a bed of heavier particles forms in the box above the screen (Figure 7). This bed is alternately dilated and compacted by the pulsed flow of water through the screen at up to 10 times per second. (See Appendix 4 for a commercial example.) The depth of the bed is controlled by the height of the tailboard and the volumes of feed and water are regulated such that lighter particles overflow at A (Figure 7), heavy particles are discharged from the screen at B, and heavy fine particles pass through the screen to be caught in the hutch. The concentrate is drawn off the top of the screen at intervals by means of a dam, while hutch product is removed through a valve.

If it were possible to observe the jig bed through a transparent wall, we would plainly see a substantial layered formation. At the point where the feed enters there is a mixture of light and heavy grains as well as middling particles. From the feed point out toward the tailgate or discharge, one can observe lines of mineral grains which spread, somewhat like fingers, horizontally and vertically. The heaviest minerals have the steepest trajectory and eventually separate grains merge with similar grains in a specific layer. As the discharge side of the jig cell is approached the path turns upward.

Barite is well suited to jig concentration and historically jigs have been the major system for separating this mineral. Jigs have few operating problems and are inexpensive to run, but they do require a lot of water. Jigs are particularly useful for recovering the fines from barite ores that must be treated by a process which produces rather abundant fine material.

These systems seem to be more popular in North America than elsewhere in the world. Several jig operations have, at one time or another, been used in Nova Scotia, e.g., Brookfield, Scotsville, Walton, etc.

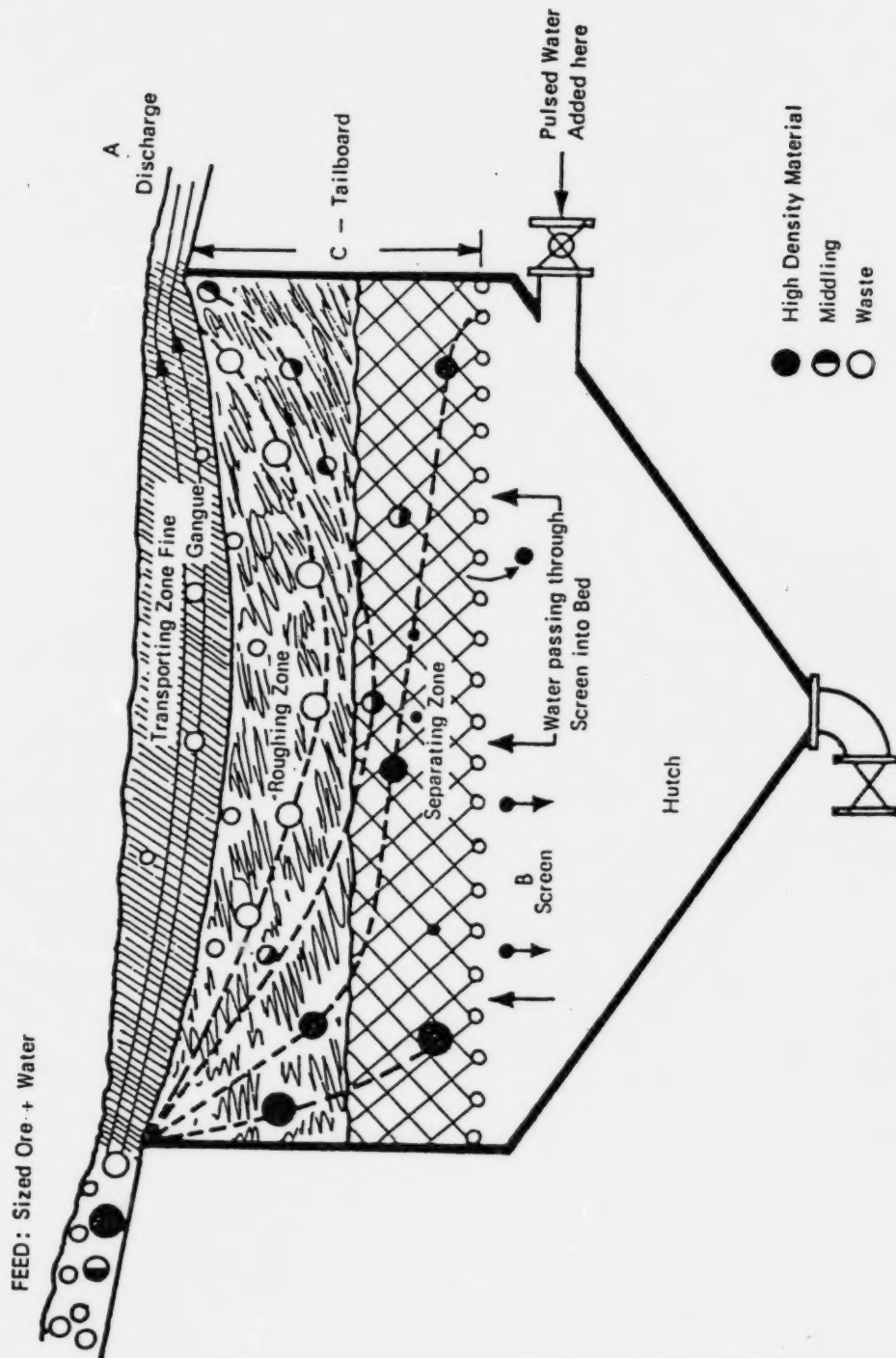


FIGURE 7 — Longitudinal Section Through a Jig, Showing the Particle Paths.

5. Ore Preparation

Crushing and grinding are common to preparatory techniques used in the milling of barite. Primary breaking is usually accomplished by either a two-stage or a three-stage crushing system depending on the characteristics of the ore and the remaining milling procedure. Where the ore is relatively coarse and the ball mill can accept a feed up to 2 cm, probably only two stages of crushing would be required; otherwise, at least three stages would be needed to liberate the barite (or other constituents). In Nova Scotia, the barite ore is not difficult to crush, so that no more than two stages are needed. Portable crushers are also in common use in Nova Scotia.

Grinding is an important step in the milling of barite ores. Because minerals such as chert, garnet, and other silicates are considerably harder than barite, there is a strong tendency to prolong the grinding cycle with the result that the barite is reduced to an extremely fine particle size. A short, stumpy mill with a grate discharge gives a minimum residence time and is generally less expensive to operate than a regular mill, although considerably noisier. Installing an early-stage classifier would scalp out the barite as soon as it is ground to flotation size. Trunnion-discharge ball mills tend to result in over-grinding of the barite. Long grinding mills give rise to slimed barite. Any material finer than 5 microns will go to waste because there is no processing equipment to handle it.

IV. MARKETING OF BARITE

A. Characteristics of Barite

The special characteristics of barite make this mineral particularly useful to the petroleum, construction, and chemical industries throughout the world. Of particular importance is barite's relatively high density (SG = 4.48), relatively soft fabric (H = 2.5-3.5), and its insolubility with respect to water, acids and alkalis.

B. Uses of Barite

Barite is used most commonly as an aggregate for drilling muds and heavy concretes and as a base for deriving numerous barium compounds. Specifications are dictated by the use and have been issued by API, ASTM, US Corp of Engineers, etc.

1. Drilling Muds

At least 80% of all barite produced in the world is used as a weighting agent in drilling muds. Besides its relatively high specific gravity, barite is also non-magnetic, chemically inert, easily milled, readily available, and not expensive. This makes barite the primary mineral for drilling muds.

When ground to -325 mesh and mixed with water and other additives, this mineral produces a heavy mud which is an important constituent in well-drilling operations. Specifically, the mud is used:

1. To remove the cuttings from the bottom of the borehole and carry them to the surface.
2. To cool and lubricate the drill string and drill bit.
3. To coat the sides of the borehole with an impermeable cake.

4. To control subsurface pressures.
5. To hold cuttings and heavy material in suspension when circulation is interrupted.
6. To release sand and cuttings at the surface.
7. To support part of the weight of drill pipe.
8. To reduce to a minimum any adverse effects on the formation adjacent to the hole.
9. To ensure maximum information about the formation penetrated.
10. To transmit hydraulic horsepower to the drill bit.

The proportions of the various additives including barite can be varied to change the specific properties of the mud so that the particular requirements of a given drilling operation can be accommodated. API specifications for drilling-grade barite state that it should have a minimum specific gravity of 4.2 (see Appendix 5 for details). The volume of mud used in any operation depends on the capacity of the hole and the mud-density requirements, i.e. the pressures encountered. Current consumption is close to 1 tonne for each 30 m of hole drilled, but this can vary widely depending on numerous conditions. About 5 to 10% of drilling muds use oil instead of water as the fluid medium. Oil-based muds are used to drill troublesome shales and contaminated zones, and to minimize formation damage in possible production zones.

Despite the versatility of barite, substitutes are common. The use of hematite makes a mud of lower viscosity and therefore lower drilling costs. Although it is somewhat more abrasive, grinding to less than 200 mesh reduces this problem below the similar effect of the silica impurities in barite. Siderite muds are soluble in hydrochloric acid and to some extent in formic acid so that they are useful as a completion mud. However, its lighter specific gravity (3.7 to 3.9) makes siderite less useful as a weighting agent (i.e., muds of 2.3). Dolomite disbursts more easily in oil-based muds, is soluble in hydrochloric acid, and seems to help in alleviating loss-of-circulation problems. It, too, has a low specific gravity (2.6 to 2.8) so that the specific gravity of the mud is only 1.4, and not at all useful as a weighting agent. Galena, on the other hand, with a specific gravity of 7.4 to 7.7 can create the extremely heavy muds needed to control abnormally high pressures. However, it is expensive and therefore seldom used. Ilmenite (S.G.=4.6), celestite (S.G.=4.0), and limestone have also been used as substitutes for barite.

2. Heavy Concrete

Heavy concretes are sometimes needed for specialized purposes. Generally, they must not only be heavier per unit volume than normal concrete but must also be resistant to the expansion and contraction of the freezing-thawing cycle, to the corrosive reactions of salt water, and to the abrasive attack of fluid-borne sand grains. Such heavy concretes have been used for casements and saddles along subsea pipelines, for counter-weights and dead-weights where the high weight-to-space ratio is a critical factor, and for walls and floors where the high density-to-space ratio provides radiation protection.

Special heavy concretes with these characteristics can be produced by adding crushed barite as part of the concrete aggregate. Such concretes can weigh as much as 3.7 g/cm³; normal concretes weigh about 2.4 g/cm³. The most commonly used substitutes for barite are magnetite and ilmenite, but ferrophosphates, and steel and lead shot have also been used.

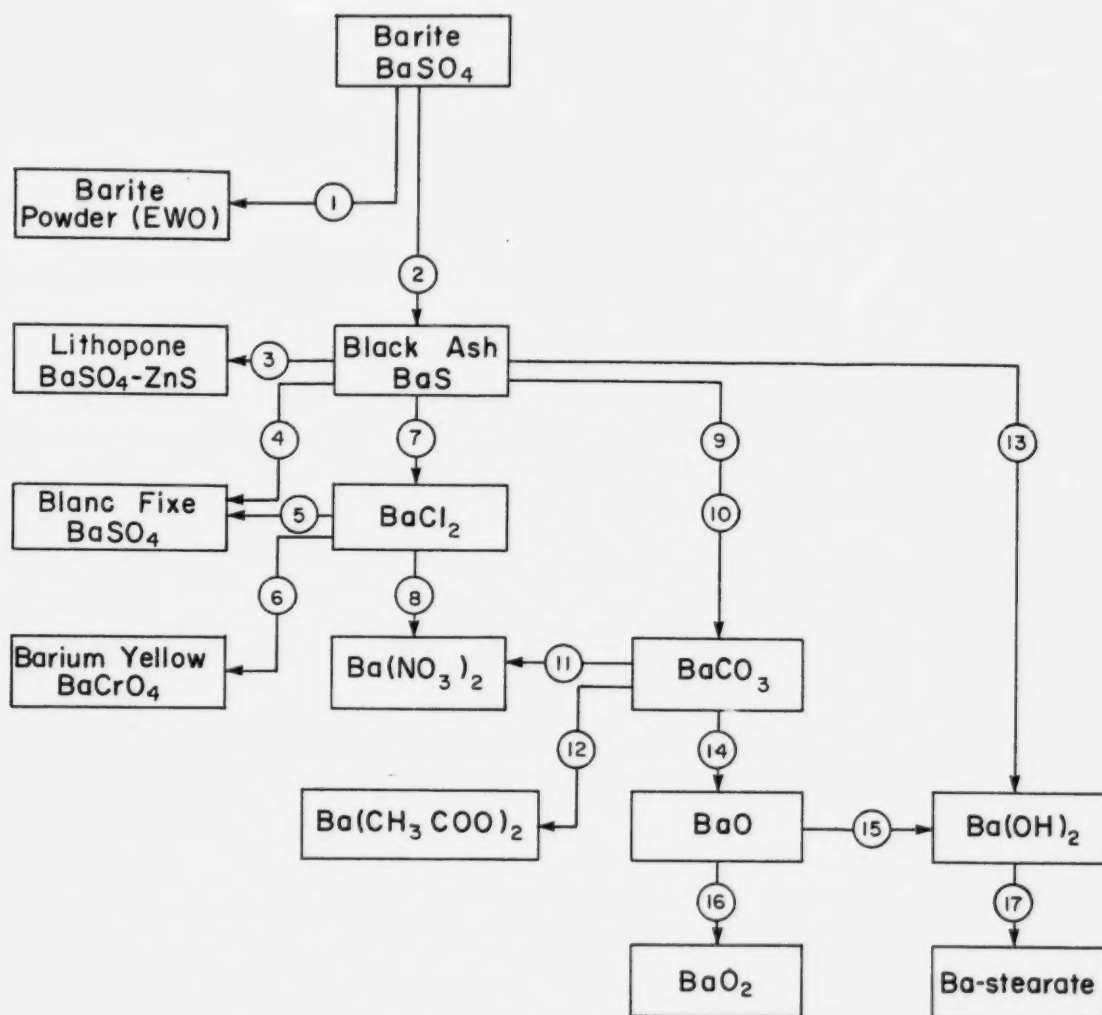
3. Chemical Compounds

The second largest consumer of barite is the chemical industry, using 8 to 9% of the world production, mainly for high-quality chemical products. The barium compounds derived from barite have hundreds of applications, mainly due to the special properties of high density, high reflectivity, and high absorption of radiation. Specifications for chemical-grade barite are shown in Appendix 5.

Barium compounds are made from barium sulfide which is produced directly from barite by the Black Ash Process (Figure 8). The barium sulfate (i.e., barite) is reduced by mixing with finely powdered coal and by heating the mixture to a temperature between 1100 and 1250°C in a rotary kiln. The end product contains 80 to 85% barium sulfide, depending on the impurities in the starting materials. Further impurities are removed by counter-current leaching of the furnace clinker with water and by filtration to produce a barium sulfide solution and a leach residue containing most of the impurities.

Four barium compounds comprise most of the by-products used in the chemical industry: barium carbonate, BaCO₃; barium sulphate, BaSO₄; barium chloride, BaCl₂; and barium hydroxide, Ba(OH)₂.

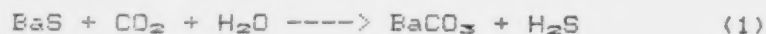
(a) Barium Carbonate Barium carbonate is the most abundantly (50%) and widely used of all barium compounds, with applications in a variety of glass products, in ceramics, in



1. Milling and Bleaching
2. $\text{BaSO}_4 + 4\text{C} \rightleftharpoons \text{BaS} + 4\text{CO}$
3. $\text{BaS} + \text{ZnSO}_4 \rightleftharpoons \text{ZnS} + \text{BaSO}_4$
4. $\text{BaS} + \text{Na}_2\text{SO}_4 \rightleftharpoons \text{BaSO}_4 + \text{Na}_2\text{S}$
5. $\text{BaCl}_2 + \text{Na}_2\text{SO}_4 \rightleftharpoons \text{BaSO}_4 + 2\text{NaCl}$
6. $\text{BaCl}_2 + \text{KNaCrO}_4 \rightleftharpoons \text{BaCrO}_4 + \text{NaCl} + \text{KCl}$
7. $\text{BaS} + 2\text{HCl} \rightleftharpoons \text{BaCl}_2 + \text{H}_2\text{S}$
8. $\text{BaCl}_2 + 2\text{NaNO}_3 \rightleftharpoons \text{Ba(NO}_3)_2 + 2\text{NaCl}$
9. $\text{BaS} + \text{CO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{BaCO}_3 + \text{H}_2\text{S}$
10. $\text{BaS} + \text{Na}_2\text{CO}_3 \rightleftharpoons \text{BaCO}_3 + \text{Na}_2\text{S}$
11. $\text{BaCO}_3 + 2\text{HNO}_3 \rightleftharpoons \text{Ba(NO}_3)_2 + \text{H}_2\text{O} + \text{CO}_2$
12. $\text{BaCO}_3 + 2\text{CH}_3\text{COOH} \rightleftharpoons \text{Ba(CH}_3\text{COO)}_2 + \text{H}_2\text{CO}_3$
13. $3\text{BaS} + \text{O}_2 + 2\text{H}_2\text{O} \rightleftharpoons 2\text{Ba(OH)}_2 + \text{BaS}_3$
14. $\text{BaCO}_3 + \text{C} \rightleftharpoons \text{BaO} + 2\text{CO}$
15. $\text{BaO} + \text{H}_2\text{O} \rightleftharpoons \text{Ba(OH)}_2$
16. $2\text{BaO} + \text{O}_2 \rightleftharpoons 2\text{BaO}_2$
17. $\text{Ba(OH)}_2 + \text{Stearic Acid} \rightleftharpoons \text{Ba - Stearate}$

FIGURE 8: Derivative Compounds of Barite

ferrites and titanites used for the electronics industry, and in many other products. It can be produced from barium sulfide by two different chemical processes:



The glass industry is the major consumer of barium carbonate where it is used as a source of barium oxide. This compound improves the quality of glass by imparting to it a higher refractive index, greater hardness, improved clarity, and a more effective radiation filter for television cathode-ray tubes. Because strontium carbonate improves picture brightness and absorbs even greater amounts of the gamma radiation, this compound has generated some competition for barium carbonate. Each has established its market which remains quite stable at the present time.

The ceramic industry consumes approximately 25% of all barium carbonate produced. It is used to bind the soluble sulphates (gypsum) in the raw material of ceramic products, to form insoluble barium sulphates from materials (e.g., sulphides) which would otherwise cause a discoloration of bricks, and to prevent efflorescence on the surface of fired bricks. Barium oxide, produced from the carbonate, is usually added to glaze mixes of ceramic products to improve the resistance to abrasion and leaching by mild solvents.

The ceramic industry also requires barium titanate (BaTiO_3) and barium ferrite ($\text{BaFe}_{12}\text{O}_{19}$) to make some specialized electronic parts. Barium titanate in microcrystalline form has a high dielectric constant so it is very suitable for the manufacture of small condensers used in computers, telecommunications equipment and electronic automotive parts. Barium titanate in crystal form is used in depth-sounding transducers, sonar instruments, geophones, and other electronic gear.

Barium ferrite is a stable magnetic material with a large crystal anisotropy and a high coercive force. This means that it has the ability to withstand strong adverse magnetic fluxes through wide temperature ranges without suffering permanent loss of its magnetization. It is therefore used in telephones, earphones, microphones, dynamic speakers, electric clocks, DC motors, and windshield wiper motors.

To form barium ferrite, barium carbonate is mixed with iron oxide and fired in a kiln where the following reactions occur:



Barium carbonate is also the base from which other barium compounds such as barium nitrate $[\text{Ba}(\text{NO}_3)_2]$, barium acetate $[\text{Ba}(\text{C}_2\text{H}_3\text{O}_2)_2]$, and other water-soluble salts can be made. These compounds are primarily used for the removal of sulphate, heavy metal, and alkali earth ions from aqueous solutions.

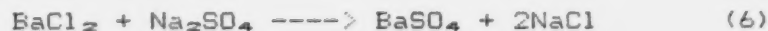
(b) Barium Sulphate Barium sulphate, or its more common name "blanc fixe", is used most commonly in paints in place of barite (which cannot be made fine enough) to form an extremely tight and dense film. Blanc fixe is valued most especially for its property of enhancing the optical characteristics of the paint with which it is mixed, for it has no pigmentary property. Blanc fixe is therefore used in coloured enamels where the colour brilliance must be maintained. Because it is also resistant to acids and alkalis, it is very useful in chemically resistant industrial paints. It is also weather resistant and so finds use in distemper and emulsion paints for indoor and outdoor decoration.

Blanc fixe is also used for coating paper because it imparts a high degree of opacity which prevents printed characters from showing through light bond paper. It provides a smooth surface, and adds brightness and finish to the paper, thereby reducing the amount of ink required. Rigid specifications have been developed for the use of blanc fixe as a paper additive. These are presented in detail in Appendix 5.

Blanc fixe forms a powder when it is chemically precipitated from a solution containing barium sulphide and Glauber's salt ($\text{Na}_2\text{SO}_4 \cdot 12\text{H}_2\text{O}$).



Blanc fixe can also be made as a paste in the following reaction:



The second procedure is carefully controlled so that the grain size of the precipitate is satisfactory for providing a quality surface to photographic papers. The extremely low insolubility of the paste precipitate also prevents any interaction between the pigment coat and the sensitive silver halide photographic emulsion.

A complex compound involving a mixture of barium sulphate and zinc sulphide, called lithopone, has

characteristics which makes it useful in primer paints for automobiles, undercoats, and some indoor emulsions. It is also used in dry artists colours, rubber pastes and putties, and in wallpaper coatings.

Blanc fixe and lithopone at one time were major products in the paint industry. However, with the introduction of titanium dioxide and other less expensive fillers, the demand for the barium compounds greatly declined. Nevertheless, as the price of titanium increased, a balance in market proportions was reached. Optical properties of TiO_2 make it more desirable than blanc fixe for paints. The refractive index of barium sulphate crystals relative to the binder is 0.95 whereas the ratio for titanium dioxide is 0.58. Values near 1.0 imply that the product is an extender while those differing greatly from 1.0 are pigments. Extenders work with pigments in paint by isolating individual pigment particles thereby allowing for maximum optical efficiency of those pigment particles.

(c) Barium Chloride Barium chloride is a useful compound in the treatment of tailings from uranium operations, particularly in Canada where uranium mining and milling is a wide-spread and increasingly troubled industry. Of special concern are the large tailings piles containing potent quantities of radioactive Radium 226 with a half-life of 1620 years. When barium chloride is added to the potentially hazardous effluents, the radium is precipitated as $(\text{Ba,Ra})\text{SO}_4$ and removed.

Barium chloride is also used in baths for the heat treatment of steels, in the preparation of metallic magnesium, and as a mordant for fixing acid dyes in the leather and textile industries.

Barium chloride may be produced directly from barium sulphide by reaction with hydrochloric acid or chlorine gas, or indirectly through the reaction of barium carbonate and hydrochloric acid.

(d) Barium Hydroxide Barium hydroxide is used as an additive in the manufacturing of some lubricating oils. The additive reacts with fatty acids to help engines run freely and to hinder the oxidation of the oil. Complex barium salts are also used to maintain the efficiency of the lubricants at elevated temperatures.

Barium hydroxide is used as a stabilizer in the plastics industry to inhibit or reduce the thermal disintegration of polyvinylchlorides during their manufacture.

Barium hydroxide is used for the recovery of sulphate and aluminum ions present in fluids used in the manufacture of paper products. These ions are precipitated as

BaSO_4 and $\text{Al}(\text{OH})_3$; this improves the opacity and texture of the paper.

Barium hydroxide is produced either by the direct oxidation of barium sulphide with oxygen or by the hydrolysis of barium oxide.



(e) Other Compounds Numerous other barium compounds find applications in a broad range of products. However, these applications are minor in comparison to the overall consumption of barite products.

Barium chlorate is used in fireworks and other pyrotechnics to produce a green colour. The compound is formed by the reaction of barium chloride and sodium chlorate.

Barium chromate, which is used as a yellow pigment for artists paints, is formed from a reaction of a barium salt and potassium chromate.

Barium hydride is used as a source of nascent hydrogen. The compound is formed by reduction with hydrogen at 200°C .

Barium manganate, which is used as a green pigment, is formed from the reaction of barium carbonate and manganese dioxide.

Barium nitrate is used to produce a green colour in flares. It is formed by the reaction of barium sulphide and dilute nitric acid.

Barium titanate, which is used in electro-ceramic products, is formed by the reaction of barium carbonate and titanium dioxide.

Barium oxide, which is used as a desiccant, is formed through the reduction of barium carbonate.

Barium fluoride is used for laser crystals and in enamels.

4. Fillers and Extenders

One of the major, non-drilling uses for barite is for fillers and extenders. A filler is a mineral substance added to a product to increase its bulk or weight, or to dilute expensive ingredients so that the final product is improved inexpensively. An extender is a mineral substance, used in paints to facilitate suspension of the pigment, to increase moisture resistance, to thicken primers for filling porous surfaces, to improve resistance to abrasion, to improve brushing characteristics, and/or to give a dull finish. Together, fillers and extenders account for approximately 0.3 to 0.5 million tonnes of barite per year, mostly in the paint industry.

The demands of fillers and extenders require the highest possible grade of barite. High-grade barite is produced by a chemical bleaching process which removes the impurities, such as iron and manganese compounds, by oxidation or reduction.

In paints, bleached barite serves the same purpose as chemically precipitated barium sulphate (blanc fixe and lithopone); that is, to optimize the optical properties of pigments in the system. Barite fillers in varnishes, water-based paints, and anti-rust primers create a high degree of impermeability and durability, thereby making them useful for undercoating, filling scratches, and resisting sanding marks. The high density, low abrasiveness, inertness, and absorption of radiation make barite fillers and extenders useful for certain rubber and plastic products such as belts, hoses, mats, gaskets and sound-proofing materials. When used with a rubber latex binder, the filler must be free of all soluble copper or manganese compounds for they would have a detrimental effect on the rubber. Some floor coverings, especially those requiring high density, malleability and ductility, may contain up to 80% high-grade barite. An inert filler must be used in many products where friction is important, such as auto brakes, clutch facings, etc.

5. Other Uses

Other uses for barite (and derived barium compounds) have been suggested. Barium sulphate is used in diagnostic medicine where it is taken orally by patients so that internal organs (stomach, bowels, etc.) can be examined for pathological changes. Also, barium sulphate could probably be added to the materials, especially plastic, used in construction of children's toys so that they would be visible if accidentally swallowed. Aprons, woven with barium-based thread, might be adequate for protecting x-ray technicians, and be much lighter than the normal lead aprons.

Barriers made from barium compounds can provide a sound shielding in noisy environments. Solid barriers and even fabric curtains containing barium sulphate will attenuate sound waves in such noisy places as airports, factories, farms, cars, and cabs of heavy equipment.

Sub-grade, drilling mud can be used as ballast in container ships. It has the ability to be slurried and could be pumped, even quickly, from one part of a ship to another. Some container ships require as much as 3000 tonnes. This use may be particularly pertinent to Nova Scotia and its maritime traditions.

C. World Production of Barite

The world production of barite has shown rapid growth over the last decade. Statistics for total production by each country are available (Table 2) along with some information on exports (Table 3) and imports (Table 4). World production of barite in 1983 is shown in Table 5.

1. Producers and Consumers

Barite occurs almost everywhere in the world. In 1980, a dozen countries contributed about 82% of the total world production of 7.7 million tonnes. Except for the four most productive countries USA (26%), China (8.8%), USSR (6.5%) and Brazil (6.5%), there seems to be little correlation between the size of the country and the size of its barite production. For example, Morocco (4.1%), Ireland (3.4%), Peru (5.8%), and Thailand (4.0%) contribute far in excess of their share with respect to the size of their countries.

These relationships are reflected in the world export trade of barite. Over 25% of all barite production is exported, with China, Morocco, and Ireland being responsible for 62% of this export market. Morocco and Ireland export all of their barite production, China almost all (87%), and France and Italy about half.

The world import trade of barite amounted to 3 million tonnes in 1980. Most of this was shipped to the United States (56%), the Soviet Union (16%) and West Germany (6.7%).

The United States is by far the largest consumer of barite, primarily because of its world-wide drilling operations. Due to this activity, the consumption of barite follows closely the demands of the petroleum industry. The markets for barite have therefore risen steadily through the 1970's but have declined somewhat in the early 1980's. On the other hand, the markets for barite as a paint filler have been

TABLE 2

Barium

Production of Barium Minerals

tonnes

Country	1976	1977	1978	1979	1980
United Kingdom	50 000	57 000	54 409	45 000	54 000
France	181 965	211 090	225 000	235 000	* 227 000
Germany, Federal Republic of	262 387	265 593	168 586	161 661	175 380
Irish Republic	323 000	373 000	343 753	319 000	260 000
Italy	179 412	152 646	236 832	214 630	203 038
Austria	81	192	242	305	249
Czechoslovakia	---	---	65 000	67 803	61 052
German Democratic Republic	* 31 000	* 31 000	* 35 000	* 36 000	* 36 000
Greece	90 620	95 794	110 841	109 344	98 529
Poland	80 342	88 700	90 300	96 000	* 96 300
Portugal	90	590	503	704	1 200
Romania	* 85 000	* 85 000	* 87 300	* 88 000	* 88 000
Soviet Union	* 400 000	* 450 000	* 475 000	* 500 000	* 500 000
Spain	91 115	84 280	71 457	74 000	* 73 000
Turkey	188 266	143 510	100 904	100 005	112 975
Yugoslavia	56 122	52 245	42 800	46 073	* 43 000
Algeria	74 543	42 303	* 73 000	* 90 000	* 91 000
Egypt	239	658	* 1 000	* 2 000	* 3 000
Kenya	359	429	303	363	6 647
Morocco	137 463	149 920	176 813	286 467	318 000
South Africa	1 915	2 500	2 355	2 494	2 635
Swaziland	368	---	---	---	---
Tunisia	22 313	16 049	16 358	14 929	26 950
Zimbabwe	1 480	2 798	878	449	195
Canada	100 266	116 950	99 339	67 035	* 86 000
Mexico	270 063	270 674	231 485	151 162	269 322
USA (b)	1 119 594	1 355 216	1 969 000	1 916 000	2 037 000
Argentina	40 546	30 571	45 685	54 928	* 58 000
Brazil	51 238	39 575	238 257	489 997	---
Chile	21 243	65 038	182 422	226 767	* 204 000
Colombia	3 100	3 450	3 500	* 3 600	* 3 600
Peru	330 689	434 984	362 000	436 000	* 450 000
Afghanistan (c)	5 100	14 100	12 700	2 700	---
Burma (a)	15 681	23 805	42 166	* 40 000	* 42 000
China	* 299 000	* 350 000	* 400 000	* 500 000	* 680 000
India	235 068	330 989	388 582	490 699	345 948
Iran (c)	* 230 000	* 185 000	* 200 000	* 180 000	* 150 000
Japan	66 409	72 916	77 036	53 736	* 50 000
Korea, Dem. P.R. of	* 120 000	* 120 000	* 110 000	* 110 000	* 110 000
Korea, Republic of	4 174	2 645	1 005	728	410
Malaysia	6 096	12 074	5 079	1 401	---
Pakistan	9 052	17 718	16 303	32 433	14 054
Philippines	3 199	5 393	5 548	6 667	* 6 500
Thailand	151 343	118 466	274 564	378 654	305 057
Australia	14 133	11 675	13 790	94 066	34 951
World total	5 400 000	5 900 000	7 100 000	7 700 000	7 700 000

Note: In addition to the countries listed, Bulgaria and Cuba are believed to produce barium minerals

(a) Years ended 31 March following that stated.

(b) Sold or used by producers

(c) Years ended 20 March following that stated

TABLE 3

Exports of Barium Minerals					Barium tonnes
Country	1976	1977	1978	1979	1980
United Kingdom	6 630	3 904	3 424	4 622	4 051
Belgium-Luxembourg	199	315	408	430	13 656
France	58 560	99 353	116 535	121 722	113 937
Germany, Federal Republic of	65 582	32 761	38 178	38 720	44 406
Irish Republic	...	...	322 853	302 317	272 643
Italy	24 314	20 264	73 863	89 352	105 818
Netherlands (b)	102 895	103 708	94 774	77 548	122 537
Czechoslovakia	* 1 500	* 1 200	* 8 500	7 000	8 000
Greece	33 695	36 003	48 256	38 587	55 259
Norway	13 913	13 228	4 627	1 627	272
Portugal	2 466	1 000	3	283	...
Romania	...	* 500	* 600	...	...
Spain	52 801	58 070	90 793	74 677	52 018
Turkey	175 191	154 911	124 123	95 844	...
Yugoslavia	41 665	25 309	16 495	13 965	19 077
Morocco	120 556	181 244	224 842	277 346	333 820
Swaziland	369	—	...	...	...
Tunisia	4 000	157	1 109	200	2 840
Canada	60 297	69 421	56 783	2 038	645
Mexico	106 728	122 204	98 950	134 584	...
Trinidad & Tobago	183	1 021	1 469	527	...
USA	37 402	44 952	33 179	96 117	87 833
China (d)	* 63 400	* 77 300	* 126 700	* 278 700	* 591 100
India	151 426	177 188	201 042	338 312	...
Indonesia	5 186	3 402	12 546	7 159	6 451
Israel (c)	163	761	708	82	72
Japan	...	1 250	2 894	1 002	1 902
Malaysia	1 747	895	...	...	...
Pakistan (a)	...	500	—	3 750	1 700
Singapore	42 229	40 021	35 615	52 521	37 667
Thailand	107 186	202 725	195 122	288 852	...
Australia	4 017	1 304	969	1 232	48 108

Note: Trade in barium minerals is reported under item 278.92 of the Standard International Trade Classification (Revision 2) and is described as "barytes and witherite". However, it is thought that very little, if any, witherite is traded

(a) Years ended 30 June of that stated

(b) Figure for 1976 excludes exports to Belgium-Luxembourg, if any

(c) Figures may be incomplete as value only given in Israeli trade return for exports to some countries

(d) IGS estimates, based on known imports into certain countries

TABLE 4

Barium

Imports of Barium Minerals

tonnes

Country	1976	1977	1978	1979	1980
United Kingdom	36 448	50 616	80 315	90 355	143 089
Belgium-Luxembourg	8 477	8 318	8 293	8 082	8 407
Denmark	11 264	4 471	5 863	3 951	12 461
France	11 411	11 814	8 983	14 427	14 611
Germany, Federal Republic of	124 162	175 356	196 465	197 659	201 630
Italy	7 748	18 538	13 871	13 634	7 531
Netherlands (c)	121 874	130 261	124 608	201 694	81 728
Austria	4 008	3 785	6 976	3 227	5 752
Finland	1 272	1 154	952	1 224	1 168
Norway	51 589	61 121	63 204	102 981	111 392
Poland	35 058	14 280	21 653	...	...
Portugal	485	413	458	645	1 979
Romania	* 3 900	* 4 000	* 8 900	...	...
Soviet Union	* 350 000	* 400 000	* 450 000	* 450 000	* 500 000
Spain	10 197	809	3 321	2 518	850
Sweden	6 153	5 390	4 660	5 493	3 992
Switzerland	3 089	3 324	2 880	2 291	3 181
Yugoslavia	760	1 110	1 206	1 204	1 147
Algeria	45 100	67 388	98 895	...	...
Cameroon	2 725	7 432	15 750	...	...
Gabon	12 894	3 577	...	...	...
Ivory Coast	106	3 243	3 505	345	...
Senegal	20	76	39	...	...
South Africa	2 685	3 444	2 437	19 168	5 621
Tunisia	8 924	3 458	1 568	2 480	233
Canada	18 097	5 979	15 635	8 390	48 749
Trinidad & Tobago	32 668	54 024	61 870	35 662	...
USA	833 257	875 280	1 191 915	1 374 721	1 702 216
Brazil	252	163	240	156	175
Venezuela	41 728	60 914	87 152	...	...
Abu Dhabi	...	...	...	1 472	16 189
Hong Kong	1 013	291	258	335	1 169
Indonesia	51 835	760	22 295	19 881	21 031
Iran (b)	206	242	...	...	...
Iraq	35 752	...	...	...	...
Japan	16 516	32 771	21 278	24 565	40 173
Malaysia	8 270	3 946	...	...	...
Philippines	272	632	1 169	1 054	1 893
Saudi Arabia	30 550	12 552	3 812	553	...
Singapore	37 481	28 532	14 858	50 774	66 343
Syria	810	123	2 326	...	...
Taiwan	7 386	2 880	10 340	2 870	7 605
Australia	1 435	1 527	541	1 189	1 273
New Zealand (a)	5 623	1 747	1 169	1 582	1 332

Note: Trade in barium minerals is reported under item 278.92 of the Standard International Trade Classification (Revision 2) and is described as "barytes and witherite". However, it is thought that very little, if any, witherite is traded

(a) Years ended 30 June of that stated

(b) Years ended 20 March following that stated

(c) Figure for 1976 excludes imports from Belgium-Luxembourg, if any

TABLE 5

World Production of Barite 1981-83

Country	1981	1982 ^a	1983 ^a
Afghanistan	1	2	2
Algeria	89	102	109
Argentina	49	36	40
Australia	41	40 ^a	40
Belgium ^a	40	40	40
Bolivia	2	1	1
Brazil	116	120 ^a	118
Burma	10 ^a	20	20
Canada ^a	80	30	28
Chile	259	292	300
China ^a	798	898	1000
Colombia	4	4 ^a	4
Czechoslovakia	61 ^a	61 ^a	61
Egypt	2	3 ^a	4
France	191	156	150
Germany, Demo- cratic Republic ^a	35	35	35
Germany, Federal Republic	165	362	250
Greece	47	47	46
Guatemala	5	2	2
India	354	326	300
Iran ^a	75	80	85
Ireland	260 ^a	260 ^a	218
Italy	177	180	150
Japan	56	60	70
Kenya	6 ^a	-	-
Korea, North ^a	100	-	-
Malaysia	19	25 ^a	20
Mexico	318	364	350
Morocco	465	538	275
Pakistan	24	26	28
Peru	409	375	163
Philippines	2	9 ^a	2
Poland	85	80 ^a	100
Portugal	1	1 ^a	1
Romania	79 ^a	78 ^a	78
South Africa, Republic of	3	4	6
Spain	53	50	50
Thailand	307	331	188
Tunisia	25	31	20
Turkey	186	107	80
U.S.S.R. ^a	508	517	517
United Kingdom	63	81	85
United States	2585	1674	684
Yugoslavia	45	45 ^a	40
Total	8200	7493	5760

(x1000 tonnes)

Source: United States Bureau of Mines.
^a Estimated; ^b Preliminary; ^c Revised.

static, and for chemicals, have even declined.

The following account is a summary of the available information for some of the most important barite producing countries and for Canada.

(a) United States With an annual production near 2 million tonnes, the United States dominates the world markets for barite. The country has 35% of the known world resources of barite which are centred in the State of Nevada, which accounts for 85% of the total US output. Other important barite-producing states are: Missouri, Arkansas, Tennessee (most of which goes into paints), and Georgia (most of which goes into pharmaceutical products). Demands from drilling activity during the 1970's pushed barite production in the United States to record levels. Even so, imports were needed from China (40%), Chile (16%), Peru (16%), and Morocco (12%). However, with the rapid decline in drilling activity in the early 1980's, there was a parallel decrease in barite production, especially in US domestic operations. Imports were less affected because of signed long-term contracts and lower freight rates, making transportation of imported barite more economic. Still, domestic low-grade deposit continued to be developed because this material, along with equally low-grade barite from Chile, could be blended with the high-grade barite from China. The four largest corporate producers are Baroid Division of NL Industries Inc., Magcobar Minerals Division of Dresser Industries Inc., Milchem Inc., and IMCO Services. All are international, vertically integrated companies.

(b) West Germany Formerly Europe's largest producer, West Germany's output of barite declined during the 1970's. This reflected a general decline in demand for high-quality products suitable for the manufacture of barium compounds. Historically, over 70% of the barite production has gone into lithopone and other barium compounds, 25% in various filler applications, and only a minor proportion (5%) has been consumed in oilwell drilling. However, much like the drilling industry, the manufacturers of barium compounds operate their own captive barite sources, the main reason being to safeguard supplies for their integrated operations. One of West Germany's two major producers is Sachtleben Bergbau GmbH who have mines at Wolfach and Dreisler producing 60,000 tpa of filler-grade barite. The other is Deutsche Baryt-Industrie Dr. Rudolf Alberti and Co. (jointly owned by Kali-Chemie AG and Metallgesellschaft AG) which produces 50,000 tpa filler-grade, and 5000 tpa chemical-grade barite from deposits at Bad Lauterberg. Processing techniques include dense media separation, flotation and chemical bleaching.

(c) Mexico Mexico's production of barite has risen sharply over the last few years in response to the demands for

drilling fluids by the state-owned oil company Petroleos Mexicanos S.A. (PEMEX). The major barite deposits occur in northeastern Mexico and at several locations spaced across Mexico at the latitude of Mexico city. What is destined to be Mexico's largest deposit is currently being developed by Fideicomiso No Matalicos Mexicanos in the northwestern part of the country. Currently the major corporate producers are Baramin de Mexico S.A., Barita de Apatzingan, and Minerales de Colima S.A.

(d) France France is a major producer of barite, consistently producing 200,000 to 225,000 tonnes per annum. This production comes mostly from deposits near the margins of the Massif Central, the largest ones being located 50 km south of Chateauraux in central France. Five companies currently account for virtually all the barite produced by France. Societe Barytine de Chaillac produces 118,000 tpa, 85% of which is used for making barium compounds by its parent company Kali-Chemie AG of West Germany - one of the world's leading producers of barium compounds. Societe de la Vieille Moutagne (SVM) produces 40,000 tpa, 65% of which is used in paints. Mines de Garrot produces 15,000 tpa for surface coating applications and for nuclear shield aggregates.

(e) Soviet Union The main producing regions are in West Siberia, Georgia, and Kazakhstan.

(f) Thailand The second largest producer of barite on the continent of Asia and ranking fifth in the world, Thailand has a production that far outstrips its size or its consumption demands. It is obviously encouraged by the rapid increase in petroleum drilling operations in Southeast Asia. The principal commercial deposits occur along the highly faulted Carboniferous and Triassic granite terrain in the western part of the country. Smaller deposits also occur associated with Mississippi-Valley type lead-zinc mineralization in the central and northern regions. Only half of the barite is processed in Thailand, at Bangkok; the remainder is treated elsewhere in Southeast Asia, Australia and the United Arab Emirates. In Thailand the most prominent companies are P & S Barite Corporation and Tip Mines Co. Ltd.

(g) Ireland (Eire) Ireland's barite mining industry was transformed from a small intermittent affair into the largest in Western Europe by the initiation of lead-zinc mining in County Tipperary (south-central Ireland) where most of the production is still located. Dresser Minerals Inc. is the main producer with most of the product going to the Gulf Coast, USA. Milchem operates several mines which provide barite for drilling operations in the North Sea and in the Middle East.

(h) Italy The Italian production comes mainly from the Island of Sardinia where several deposits produce

drilling-grade barite for North Africa. Both public and private companies as well as individual entrepreneurs are active in the industry to varying degrees. Although the early 1970's saw Sardinian barite mainly going into the chemical and filler industries, the accent on drilling grades has increased. The state-owned Ente Minerario Sardo (EMSa) is the major producer.

(i) Morocco Morocco is still one of the major suppliers of barite in the world. Much of the production is exported to the USA for drilling muds there and in the North Sea, and to Norway, the Netherlands and the United Kingdom. Ste. Anonyme Cherifienne d'Etudes Minières (SACEM) produces barite from several deposits (large veins) in the western High Atlas mountains and at Imini, Khenifra and Taza. State-owned Cie. Marocaine des Barytes (COMABAR) produces barite from deposits at Djebel Igjoud and Zelmou. All these are underground operations. The ore is shipped to ports at Safi and Casablanca.

(j) India India's barite comes mostly from Cuddapah, Andhra Pradesh near Madras in southern India and most of the remainder from Alwar, Rajasthan State near Delhi in northern India. The vast majority of India's production, as much as 90% of the total, is an off-white barite containing 92 to 95% BaSO_4 . Most of this is used in oilwell drilling; the rest in paints and for barium compounds. India's barite production and trade has been hurt in recent years by conflicts between two major consuming countries, Iran and Iraq, and between government agencies and private corporations within India itself.

(k) Brazil As with other South American countries, the influence of nearby drilling activity has brought a considerable degree of US involvement within the domestic barite mining industry. Several large deposits in Bahia, eastern Brazil are mined for barite, 95% of which is consumed in well drilling operations. The largest operator is a US subsidiary in cooperation with the Brazilian government, Baroid Pigmina Industrial e Commercial SA.

(l) Chile Chile is one of the fastest growing producers of barite. Almost all of the raw ore is shipped to the USA Gulf ports where, because the ore is low grade (SG=4.1), it is blended with the high-grade barite (SG=4.35) from China. Cia. Minera Baritex, the largest producer, mines deposits in the Coquimbo, Chanaral and Copiapo areas of northern Chile. Over 125,000 tpa is produced from the deposit at Las Bombas, Chanaral, where there is a 70,000 tpa jig plant. Cia. Minera La Esperanza Ltda. is the second largest producer with 110,000 tpa.

(m) Peru Peru is one of the major producers of barite. The industry has close ties with the major drilling mud-supply companies, particularly Baroid, and much of the production is destined for the Gulf Coast market. The most important contributor to the Peruvian barite industry is Perubar SA with production from several large deposits at Huarochiri, just east of Lima. Others are the Minera Barmina SA/Minera Cecibar SA partnership and Minera Baribent SA.

(n) China China is the world's second largest supplier of barite next to the USA. It is a very high-grade product (SG=4.35) and comes from Tangshan, Hobei Province; Linchuan, Jiangxi Province; Hsui-jin, Guangxi Province; and from Shandong Province. Most of this production is exported to the USA markets where it is used mainly for drilling muds and some for chemical compounds, and recently to the drilling industry in Mexico. Hong Kong-based KCA Minerals has been especially prominent in the development and trade of Chinese barite.

(p) Canada Canada has not been a major producer of barite. Mountain Minerals Co. Ltd. produces drilling-grade barite from old lead-zinc-silver mines and tailings piles at Mineral King, Brisco and Parson in southeastern British Columbia. This is shipped to its grinding mill at Lethbridge, Alta. Extender Minerals of Canada Ltd. produces filler-grade barite from a vein deposit at Matachewan, Ontario. Nystone Chemicals Ltd. mines drilling-grade and pharmaceutical-grade barite from its deposit near Brookfield, Nova Scotia. A recent joint venture between Abitibi-Price Inc. and Asarco Inc. recovers barite on a seasonal basis from accumulated tailings at the Buchans base-metal mine in central Newfoundland. As much as 2 million tonnes of barite ore, grading between 5 and 40%, has recently been found associated with the large, newly discovered gold deposits at Hemlo, Ontario.

V. BARITE IN NOVA SCOTIA

While Nova Scotia is not a major producer of barite and is therefore not a significant market influence, this province does have numerous occurrences which may have strategic uses. The following section describes the general geology of Nova Scotia, the types of barite deposits found in Nova Scotia, and a genetic relationships of their occurrences.

A. Geologic Setting

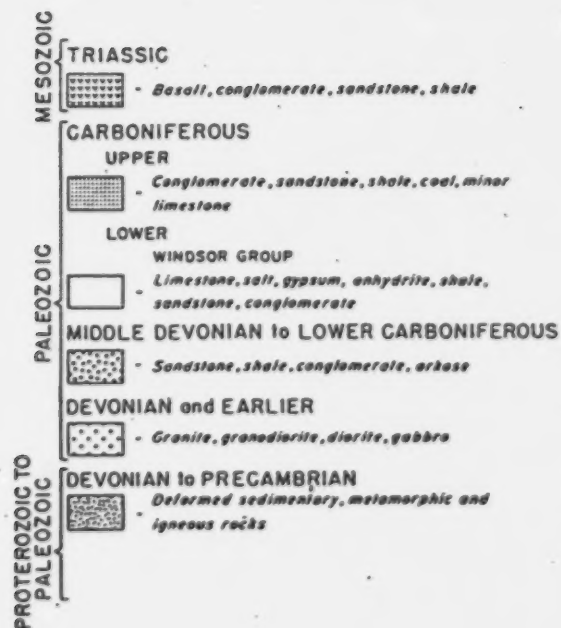
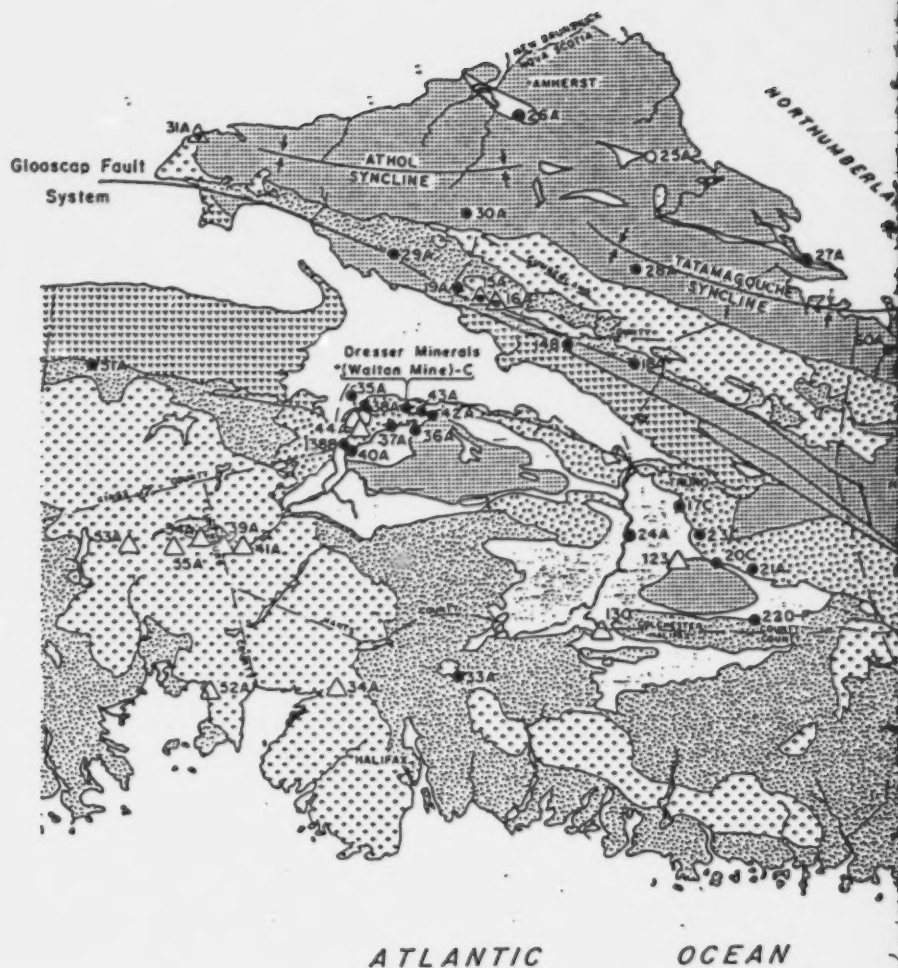
The following section is a brief description of the general geology of Nova Scotia. Reference may be made to the map shown in Figure 9.

1. Precambrian

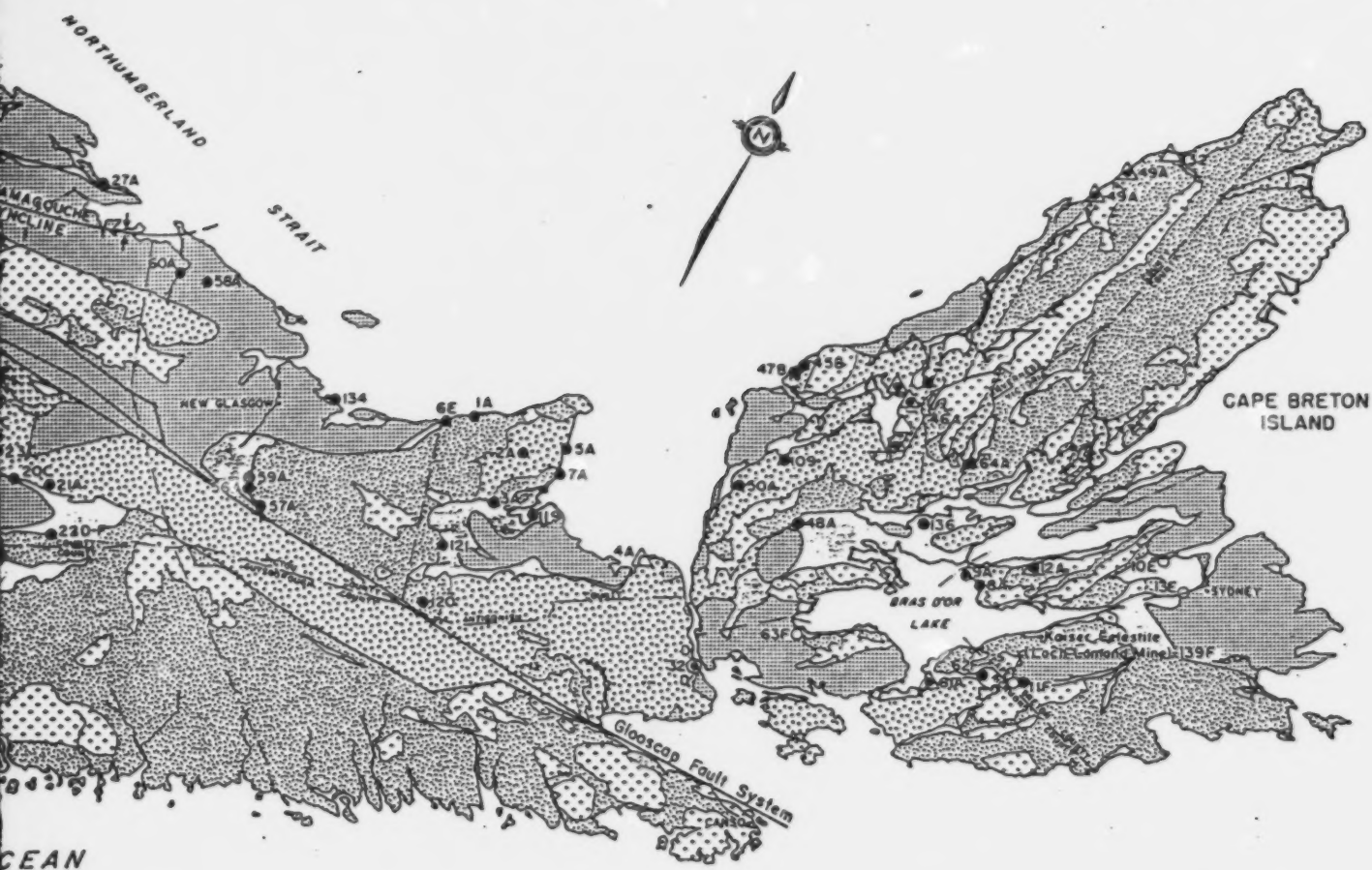
In Nova Scotia the Precambrian rocks are largely concealed beneath a cover of Paleozoic and younger strata. The largest exposed area is in the Cape Breton Highlands and another belt is confined to the eastern half of Cape Breton. These ancient rocks consist of a complex of metasediments - folded and faulted schists, gneisses, limestones and dolomites, together with complex igneous intrusions. They have been divided into two separate units known as the George River Group and the Forchu Group respectively.

2. Paleozoic

(a) Cambrian The only area in which rocks of Cambrian age are known is in eastern Cape Breton. The oldest of these rocks are shales, sandstones and conglomerates and lie on Precambrian rocks without any apparent break and pass upward into the fossiliferous Cambrian sediments. The remainder of the Cambrian sequence in Cape Breton is divided into a number of different formations. There are several breaks in the series as indicated by the fossil content. Small stocks of granite invaded the Cambrian rocks during Devonian time and extensive folding occurred.



Source: NSDME



CEAN

LEGEND

Occurrence	No.	Style	Occurrence	No.	Style
Arrows Point	1	A	Johnson Cove	38	A
Big Marsh	2	A	Lemmer	39	A
Brerry Brook	3	A	Lower Burlington	40	A
Cape Blue	4	A	Vaughan-Lemmer Road	41	A
Lakeville	5	A	Walton (gravel)	42	A
McAras Brook	6	E	Whiston Brook	43	A
Metesac Point	7	A	White Head	44	A
Shenocodis Point	8	A	Foley Point (Mill Brook)	45	B
Durby Point	9	A	Lake Annapolis deposits	46	A
Frenchville Brook	10	E	Wolfe Mines	47	B
Salmon River Road	11	F	Wolfe	48	A
Shenocodis	12	A	Presqu'ile - Carney	49	A
Sydney River	13	E	Brook Area	50	A
Bott River	14	B	Rear Judsons South	51	A
Bott River of Five Islands	15	A	Nicholsville	52	A
East River of Five Islands	16	A	Forten Settlement	53	A
Hidden	17	C	Lower Cones Lake	54	A
Lemmer	18	A	New Russell (Walker)	55	A
Lynn Road	19	A	Prospect	56	A
Middle Stewacks	20	C	Bridgeville	57	A
Smithfield	21	A	Gloucester Brook	58	A
Southville	22	D-F	Hudson	59	A
Upper Brookfield	23	C	Springville	60	A
Urbans	24	A	Wolfe	61	A
Southville	25	A	Gutter Creek (McNess)	62	F
Brookville	26	A	Cave Area	63	F
Monaghan North Shore	27	A	Pine Brook	64	A
North Greenville	28	A	Rear Glass River	65	A
Parrsboro	29	A	Tonnes (Lies)	66	A
South Brook	30	A	Upper Southwest Harbor	109	
Spicer Cove	31	A	Culpe Quarry (Southside)	110	
Sydney Brook	32	B, D	Litchford Lake	120	
Upper Tannan	33	A	MacLean Shaving (Chile)	121	
Chloride	34	A	Little River (Brentwood)	122	
Faithwinder Property	35	A	Sydney River	130	
Goshaw	36	A	Pleasant Bay	132	
	37	A	Melmerby Beach	134	
			Lynn Harbour (Hillside)	136	
			Prospect	138	B
			Summerdale Wharf	139	F
			Lock Leonard	139	F

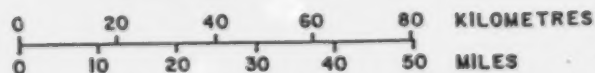
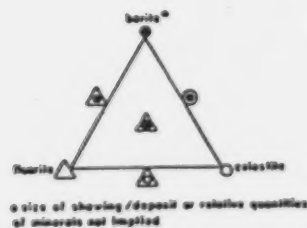


FIGURE 9 GEOLOGY MAP OF NOVA SCOTIA

(b) Ordovician Ordovician rocks are sedimentary but have been extensively metamorphosed by volcanic and intrusive magmas and lavas.

Rocks of the Meguma Group (Gold-Bearing Series) are believed to be Ordovician or earlier in age and extend the entire length of the mainland from Yarmouth to Canso. The Meguma Group consists of a great thickness (20,000 - 35,000 feet) of conformable quartzitic greywacke and slate. The entire group is remarkably lacking in fossils and its age is assessed somewhat doubtfully by the existence of Ordovician fossils in a narrow belt of rocks exposed south of Kentville. This belt is cut off from the main body of Meguma sediments by a granitic intrusion.

The Ordovician Meguma Group has been closely folded into anticlines and synclines. In addition, there are some cross-folds, giving rise to a series of domes. The granitic masses that cut them are of Devonian age. Gold occurrences are numerous in the Meguma.

(c) Silurian The best section of Silurian strata in Nova Scotia is at Arisaig, Antigonish County, where there are 2 1/2 miles of good exposures of tilted and folded sediments consisting of sandstone, argillaceous sandstone, siltstone, shale and volcanic rock. The basal Silurian beds rest unconformably on Ordovician rhyolites and tuffs. Fossils are plentiful and deposition took place in a relatively shallow sea, the floor of which subsided to accommodate the 4,000 to 5,000 feet of sediments.

Silurian fossils have also been found in shale and sandy shale in the metamorphic complex of the Cobequid Mountains.

(d) Devonian Rocks of Lower Devonian age occur in Nova Scotia in the vicinity of Arisaig where over 1,000 feet of red sandy shale and sandstone carry remains of freshwater fish. Sedimentation during the Devonian was accompanied by widespread volcanism, and at the close of the epoch, extensive deformation took place known as the Acadian Orogeny. Devonian intrusive rocks, chiefly granitic, occur in a broad irregular belt extending from the extreme west end of the province to Cape Canso and throughout Cape Breton Island.

(e) Carboniferous Numerous areas in Nova Scotia are underlain by Carboniferous strata. These strata are the Province's source of coal, oil shale, salt, limestone, dolomite, celestite, barite, gypsum and anhydrite. Rocks of the Lower Carboniferous (Mississippian) period are divided into the Horton and Windsor Groups. The Horton Group consists of continental deposits of conglomerate, sandstone and dark shale. Remains of fossil plants and buried forests occur and there are some thin localized coal seams. Fossil fish also

occur and provide evidence of brackish lakes.

The Windsor Group consists of marine sediments. These include sandstone, shale, conglomerate, limestone, dolomite, gypsum, anhydrite and salt. Above the basal limestone, most of the limestones are very fossiliferous. It is within the Windsor Group that the majority of industrial minerals are mined. Total thickness of the Windsor Group varies from 1,000 feet to 10,000 feet.

The Upper Carboniferous (Pennsylvanian) rocks in Nova Scotia are continental in origin, and were laid down during a period of crustal unrest resulting in alternate rising and sinking of the land areas. They consist of rather uninteresting red and grey sandstone, conglomerate, siltstone, and shale which contain thin bands of dark carbonaceous and calcareous shale.

The coal deposit of the Pennsylvanian have long been of considerable economic importance. They were formed in the flat areas near the centres of the individual basins where river flood plains encouraged the growth of luxuriant vegetation with a swampy environment. Accumulation of great thicknesses of vegetable matter could only take place under rather stable conditions and then renewed tectonic activity buried the deposits under floods of sediment. The coals differ in age in the various coal basins.

Following the Carboniferous era, there was a period of erosion caused by folding and a general uplift of the land. This continued for about 55 million years or throughout the Permian era.

3. Mesozoic

(a) Triassic The youngest consolidated rocks in Nova Scotia are of Triassic age. The Annapolis-Cornwallis Valley, and both sides of the Minas Basin, are underlain by the Annapolis Formation of sandstone, shale and conglomerate. A few fossil plants and some reptilian remains have been found. These rocks are capped by about 1,000 feet of amygdaloidal basaltic lava forming the North Mountain Upland. It is in this basalt that amethyst, copper, agate, zeolites and other "trap-rock" minerals are formed.

(b) Cretaceous Stratified layers of interbedded clay, quartz sand and lignite, of Early Cretaceous age, exist in the Middle Musquodoboit-Shubenacadie area of Halifax and Hants Counties. These clays and sands are overlying rocks of the Windsor Group and are covered by Pleistocene boulder clay. Economically the clays are kaolinitic, grading from low duty to high duty refractory materials, while the quality of the sands varies from 80 per cent to a high of 98 per cent silica.

4. Cenozoic

(a) Pleistocene The final event in the story of the geology of Nova Scotia was the glaciation which deposited a thick mantle of bouldery clay that hides from view most of the bedrock beneath. Other features that indicate the work of the ice are drumlins and eskers. The edge of the ice sheet extended beyond the eastern shoreline of Nova Scotia and the moving ice scoured the rock surface over which it moved, plucking and grinding the rocks beneath it. Such grooved and striated surfaces are often exposed and they show that the ice came primarily from the northwest. The ice withdrew from Nova Scotia only about 8,000 years ago.

B. Barite Occurrences

Nearly 70% of Nova Scotia barite deposits occur in sedimentary rocks including conglomerates, sandstones, siltstones, shales, limestones, limestone breccias, dolomites and gypsum beds. The strata are Carboniferous, primarily Lower Carboniferous in age. The deposits, for the most part, are fissure fillings, solution-cavity fillings, pore-space fillings and replacements.

About 17% of barite deposits in Nova Scotia occur in igneous rocks such as rhyolites, welded rhyolite tuffs, aplites, granites, granodiorites, quartz monzonites, pegmatites and greisens. The intrusive rocks are Devonian and the extrusive rocks are Upper and Lower Carboniferous. The mineralization occurs as fissure fillings.

The remainder, about 13% of the barite deposits, occur in metamorphic rocks. The host rocks may be as old as Precambrian and as young as Silurian. Most are of the fissure-filling type.

1. Types of Deposits

A comprehensive study of barite occurrences in Nova Scotia was made in the mid-1970's by G. W. Felderhof (1978). He describes six "styles" of geological occurrences which, while reasonably similar to the types of deposits described in Section II of this report, give greater emphasis to characteristics found in Nova Scotian deposits. For these reasons, Felderhof's classification is suitable for purposes of this report.

Each of the styles described by Felderhof is categorized according to four geological characteristics: the physical form of the deposit, the important features controlling the mineralization, the mineralogy of the deposit and the genesis. Idealized diagrams portraying each of the

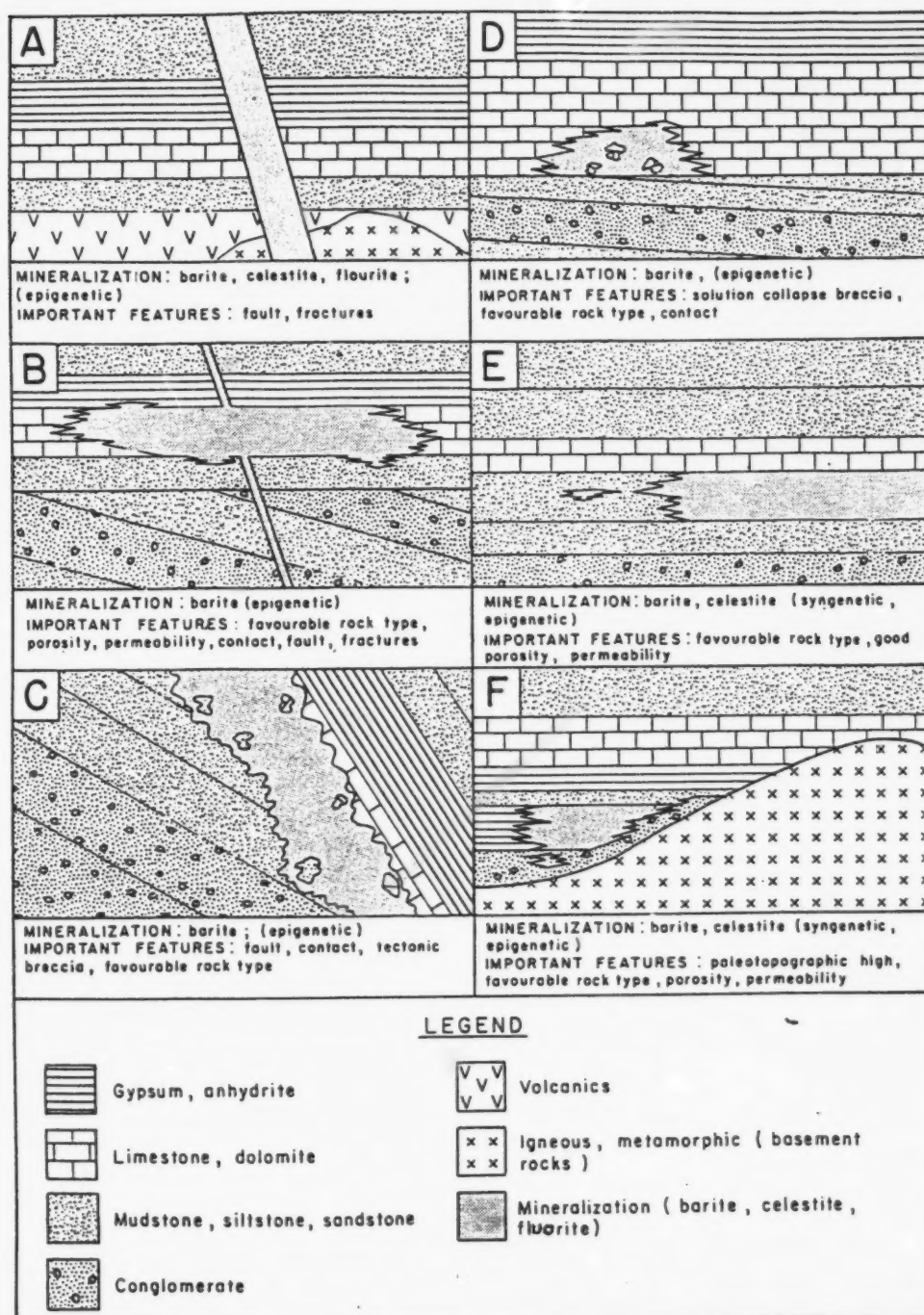
styles are shown in Figure 10.

(a) Style A Style A deposits are entirely structurally controlled, with little or no replacement of the wallrock. Faults and other planar fracture systems are therefore typical sites of mineralization. The host can be igneous, sedimentary or metamorphic rock. Such rocks adjacent to the mineralized zone are generally unaltered. This suggests that the host rocks were essentially chemically inert to the mineralizing solutions and/or the mineralizing solutions were of the epithermal type. The Scotsville deposit is an example.

(b) Style B Deposits of this style are in general stratigraphically controlled, but in detail are structurally controlled --- deposits often classified as stratabound. Each deposit varies somewhat depending on the porosity, permeability, and competency of the host rock and its favourability for being replaced by epigenetic metalliferous solutions. The overall tabular form of the deposit is usually modified on a local scale by structural features such as unconformities, faults and fractures. The deposits occur in rocks ranging from carbonate to terrigenous clastic sediments, but the carbonates and calcite-cemented siliclastic rocks are more common hosts. Although wallrock alteration is minor, replacement of the host rock by barite can be very extensive. The Bass River deposit is a good example of this style.

(c) Style C Style C deposits are primarily structurally controlled. They frequently occur at the intersection of a fault with an unconformity or of a high-angle fault with a steeply dipping limb of a fold, thereby creating abundant open spaces and tectonic breccia. The filling of the cavities and the replacement of the breccia by ore minerals results in a deposit that is often pipe shaped in general and quite irregular in detail. It may be that the ore minerals are precipitated in a zone of differential pressure as a response of the ore-bearing solutions to reach equilibrium. The host rock is not a major factor except that carbonate rocks seem to be more common. Ore zones randomly cross lithologic boundaries with no obvious difficulty. Except for some silicification of the limestone at the Walton mine, wallrock alteration beyond replacement by the barite is negligible. The Walton and Brookfield deposits are good examples.

(d) Style D Deposits of this style are both stratigraphically and structurally controlled. They occur at or near contacts separating two major rock groups, especially the Windsor-Horton contact, whether conformable or unconformable. The ore zone is usually restricted to a specific stratigraphic horizon, usually limestone, with an irregular upper contact and a more regular lower contact influenced by the stratigraphy. Barite fills cavities and



P.G.B.

NSDME

FIGURE 10: Idealized Diagrams of Six Styles of Barite Occurrences in Nova Scotia

replaces the solution (collapse) breccia. The size of the deposit depends on the extent to which brecciation has occurred or on the continuation of the favourable stratum. There is no other alteration of the host rock. The Southvale showing is an example.

(e) Style E Style E deposits are entirely stratigraphically controlled, so that they exhibit sharp contacts and a relatively uniform tabular shape. These deposits may form either from synsedimentary deposition or from replacement of carbonate or clastic rocks. The former are syngenetic in that both ore and gangue are influenced by depositional conditions in the basin at the time of sedimentation. The latter are epigenetic in that they have formed from the replacement of favourable host rocks by epithermal solutions. There is no other alteration. The McArras Brook showing is an example.

(f) Style F Deposits of this style have both stratigraphic and structural controls. Conformable beds above and below the ore bed make the deposit essentially tabular and stratabound. The nearby presence of an unconformity, such as the onlap of sedimentary strata on a topographic high of older basement rocks, is characteristic of this style. Thus, there seems to be a sympathetic relationship between the deposits and near-shore facies of the depositional basin. Some deposits terminate in gypsum in the down-dip direction. Carbonate and calcite-cemented, terrigenous clastic sediments are the most common host rocks. There is no wallrock alteration. The evidence is inadequate to determine whether this style of deposit can be classified as syngenetic or epigenetic. The Salmon River Road showing is an example.

2. Genetic Relationships

The spatial distribution of barite occurrences with respect to the geology of Nova Scotia is summarized in Figures 9 and 11.

(a) Special Features Some of the relationships between the locations of the deposits and the geology of Nova Scotia are particularly noteworthy.

1. The majority of barite occurrences have been found in Lower Carbonaceous rocks, and of these, most occur in the Lower Windsor Group.
2. A significant number of barite and barite-fluorite occurrences are situated in close proximity to the Glooscap Fault System, a large proportion of which show a close spatial relationship between northerly and northwesterly trending offset faults.

Time Scale (my)	Periods	Tectonic Events	STRATIGRAPHY			PLUTON-ISM	NO. OF EACH STYLE OF DEPOSIT						MINERALIZATION				
			Southern Nova Scotia	Northern Nova Scotia	Cape Breton Island		A	B	C	D	E	F	Ba	Sr	F		
210	Jurassic	Palisades Disturbance		Fundy Group		Province-wide											
247	Triassic																
290	Permian	Marillines															
370	Upper Carboniferous	Disturbance	Scotch Village Formation	Cumberland Gp.	Pictou Group		3	-	-	-	-	-	-	-	X	-	X
	Lower Carboniferous		UPPER LOWER	Windsor Group	Riversdale Group Canoe Group & Equiv.		1	1	-	-	-	-	-	-	X	-	X
420	Devonian	Acadian Orogeny		(River John Group)	Fossil Bk. Fm.		20	3	2	3	1	7	-	-	X	X	X
							6	-	-	-	-	-	-	-	X	-	X
444	Silurian		Torbek Fm.	Knoxville Fm.	McAdam Lake Fm.		4	-	-	-	-	-	-	-	X	-	X
			White Rock Fm.	Ariseig Gp. & Equiv. Consequ. Highlands Rocks			7	-	-	-	-	-	-	-	X	-	X
505-520	Ordovician	Taconian Orogeny					8	-	-	-	-	-	-	-	X	-	X
			Meguma Group				1	-	-	-	-	-	-	-	X	-	X
580-590	Cambrian						1	-	-	-	-	-	-	-	X	-	X
590	Precambrian	Avalonian Orogeny					1	-	-	-	-	-	-	-	X	-	X

Geology after Cook, 1973 and Keppie, 1977.

Geology after Cook, 1973 and Keppie, 1977.

P.68.

Source: NSDME

FIGURE 11: Ages of Nova Scotia Barite Deposits

3. Style A (i.e. fissure fillings) occurrences show the greatest stratigraphic range, occurring in rocks from Precambrian to Upper Carboniferous in age.
4. A large number of showings are situated at or near the Windsor-Horton contact.
5. The number of barite occurrences in the Minas sub-basin increases sympathetically with the increase in intensity of deformation of the Windsor Group.
6. A significant number of occurrences hosted by Upper Carboniferous rocks are situated in the southern limb of the northeasterly trending Athol and Tatamagouche Synclines.
7. Barium is present wherever manganese oxides occur. The barium may be included in a manganese oxide mineral such as psilomelane, and/or be present as barite.
8. The presence of hydrocarbons in the form of carbonaceous material and/or bitumen in either the host rock or in the barite deposit itself is characteristic of some occurrences.
9. Barite and fluorite is a fairly common association but only as fracture fillings.

(b) Periods of Mineralization Although the greatest period of barite mineralization took place between early Carboniferous and early Permian time, several other periods have also been identified. These are described below beginning with the youngest.

Late Triassic Age

The geology of the barite and barite-fluorite occurrences along the Glooscap Fault System in the Cobequid Highlands suggests that they are Late Triassic in age. Because these occurrences are spatially related to northerly and northwesterly trending faults which always offset the Cobequid Fault and accompany Late Triassic rifting, the mineralization must be Late Triassic. It may be that the heat from the volcanism which produced the North Mountain basalt was the driving mechanism that promoted the migration and subsequent precipitation of the ore minerals.

Early Permian/Late Carboniferous Age

Because barite has not yet been reported in Triassic rocks and because a significant number of occurrences (primarily those south of the Glooscap Fault System) show evidence of post-mineralization movement, the majority of

epigenetic barite and barite-fluorite occurrences hosted by Carboniferous rocks are Early Permian to Late Carboniferous in age. This coincides with the waning stages of the Maritime Disturbance.

Although some say that the Triassic rocks were chemically inert to mineralizing solutions, many of these rocks are petrologically similar to the mineralized Carboniferous rocks of the Horton Group. Continued movement along east-northeast and northwest striking faults during the Palisades Disturbance may have been responsible for a large portion of the deformational features in the mineral deposits in the western section of the Horton Group and Windsor Group. These same movements resulted in similarly striking, unmineralized faults in the Triassic rocks.

Volatiles associated with plutonism and volcanism during Lower Carboniferous and early Upper Carboniferous time may have been instrumental in contributing additional essential ions (e.g. Ba, Sr, F, etc.) to the solution-bearing faults, fissures and sedimentary strata. In the instances where a spatial relationship could be postulated between this igneous activity and mineralization, e.g. the Lake Ainslie deposits, it is possible that decreasing temperatures which followed the termination of igneous activity were responsible for the precipitation of the minerals.

Early Carboniferous Age

Where a syngenetic origin can be demonstrated for deposits hosted by Lower Carboniferous, Windsor Group rocks, the mineralization is the same age. The McArras Brook showing may be an example.

Middle and Late Devonian Age

Barite occurrences which are spatially and genetically related to the igneous intrusions accompanying the Acadian Orogeny are Middle and Late Devonian in age. Occurrences at Lake Fletcher, Halifax Co.; Shenacadie, Cape Breton Co.; and Nicholsville, Kings Co. are examples.

(c) Structural and Lithologic Associations Many Nova Scotia barite deposits occur closely associated with major structural or lithologic features. Six of these associations are described below.

The Windsor-Horton Contact

The Windsor-Horton contact has long been recognized as a highly favourable host for barite (as well as for metallic sulphides) because the Walton barite-Cu-Pb-Zn-Ag mine is on it. This deposit is pipe-shaped (Style C) and directly reflects the high degree of deformation to which the host

rocks have been subjected. This style of deposit is unlikely to occur at undeformed sections of the Windsor-Horton contact. Styles A and B also occur in the structurally deformed regions.

The Windsor Pre-Carboniferous Basement Contact

The contact between the Windsor Group, usually the Lower Windsor, and the underlying pre-Carboniferous basement rocks has been the locus of some barite deposits. Barite occurs, for example, at Southvale, Colchester Co., where Windsor rocks lie on the early Paleozoic Halifax Formation, and at Bridgeville, Pictou Co., where Windsor strata lie on Silurian and Devonian metasediments. In the latter case, the mineralization appears to be related to erosional irregularities in the basement metasediments which formed before the Windsor was deposited. This deposit may also be genetically related to the Glooscap Fault System which is nearby.

Genetic styles A, B, D and F are most common.

The Glooscap Fault System

Barite deposits in close proximity to the Glooscap Fault System are almost invariably hosted by metasedimentary rocks of Silurian age or older. It appears that any favourable structures, particularly north-south faults, associated with this fault system hold promise for barite. The only exception is the Bass River deposit which is hosted by Upper Carboniferous rocks.

Genetic styles A, B and possibly C are most common.

The Upper Carboniferous Rocks

The barite occurrences in Upper Carboniferous sedimentary rocks are structurally controlled, all being of the fissure-filling type (Style A) with the exception of the Bass River deposit (Style B). These deposits, all in Cumberland and Pictou Counties, are spatially related to the Athol and Tatamagouche Synclines. Although no genetic relationship has been proven, it would be reasonable to suggest that the dislocations and breccia zones of the deposits are structurally related to these folds.

Genetic styles A, B and possibly E are most common.

No other deposits have been reported in Upper Carboniferous rocks elsewhere.

The Upper Windsor Group Rocks

The Upper Windsor Group of rocks have recently

yielded a few barite occurrences. Two of the deposits occur in structurally deformed strata (Styles A and C) near a major fault or an unconformity. A few other deposits are stratigraphically controlled (Style E), being essentially replacement types.

The Pre-Carboniferous Metamorphic Rocks

Except for those near the Glooscap Fault System, barite occurrences are not common in pre-Carboniferous metamorphic rocks. Only three have been located; all are of the fissure-filling type (Style A). Their proximity to igneous intrusions younger than the host rocks suggests there may be a genetic relationship.

C. Selected Deposits

Six deposits have been selected from known barite occurrences to provide examples of Nova Scotian deposits. Besides illustrating the different styles, each deposit has had some level of operation and has a recent history. Information has been summarized from journal papers, assessment files, open-file reports and corporate files. Visits were also made to some deposits.

1. Brookfield

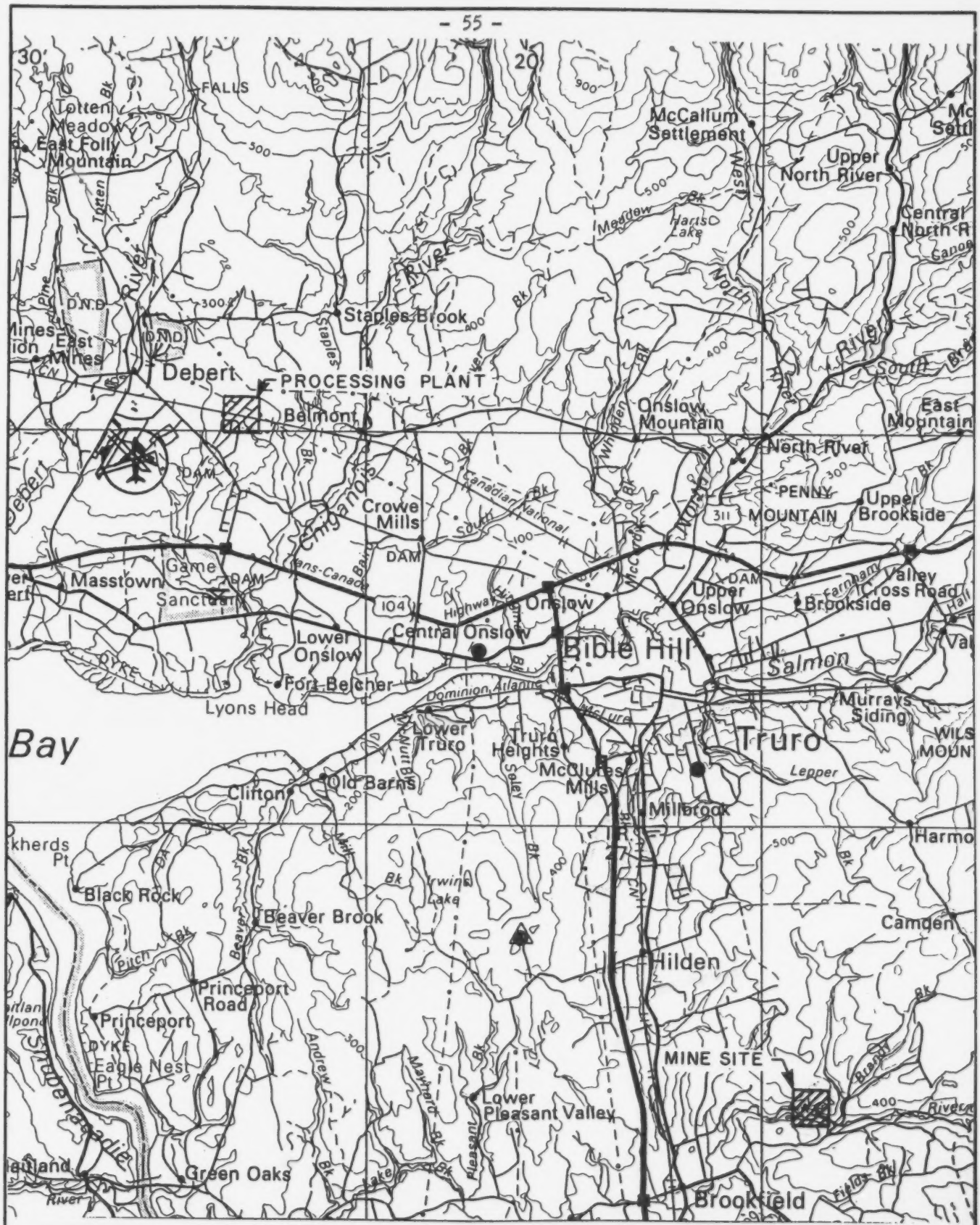
The Brookfield Mine is located approximately 12 km south of Truro and 3 km northeast of the town of Brookfield (Figure 12). The deposit occupies the top and southern flank of a hill just north of Little River.

(a) Geology The Brookfield barite deposit lies in the terrigenous clastic sedimentary rocks of the uppermost Horton Group and just below the Windsor-Horton unconformity (Figure 13). Numerous tight folds and high-angle faults indicate that these rocks were strongly deformed in post-Carboniferous times.

The deposit occupies the crest of a fold which plunges easterly and is cut off to the west by a high-angle fault striking 070° azimuth (Figure 14). Drilling indicates that it is a pipe-like body dipping 65° northwesterly and plunging 50° easterly (Figures 15 and 16). The deposit contains beds up to 30 cm thick of brecciated, ferruginous shales and siltstones which strike 120° azimuth and dip 50° northeasterly.

The ore is an intergrowth of white, coarsely crystalline barite and brown siderite. Less common is a grayish to orange, cryptocrystalline to medium-grained barite either intimately associated with fine to medium-grained siderite or cementing brecciated coarse-grained siderite. Together the barite-siderite association fills cavities and replaces breccia zones generated by the folding and faulting. Although the ore zone is contained entirely within the shale, siltstone and sandstone of the Horton Group, the replacement appears to have favoured the gray shale over the red shale or other clastic rocks. The siderite content increases toward the south but decreases with depth. There is also minor quartz and calcite.

Relationships between structural features and the mineralization indicate that deformation occurred before, during and after the mineralizing episode. In many respects the deposit resembles the Walton deposit (i.e., it is a pipe-like body in a fold-fault intersection at the Windsor-Horton contact); however, the Brookfield deposit is smaller, lacks



LOCATION MAP OF BROOKFIELD
MINE SITE & PROCESSING PLANT

Scale:
1:125,000

FIGURE 12

Date:
9/10/85

Dwn. By:
V.A.H.

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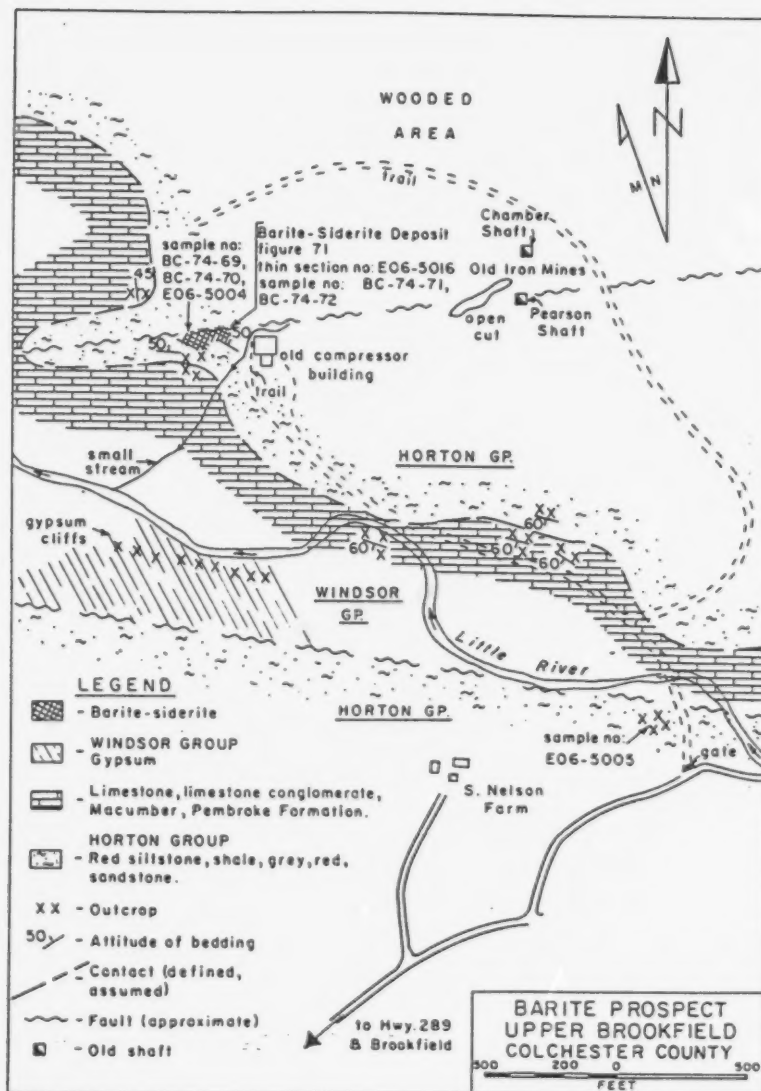
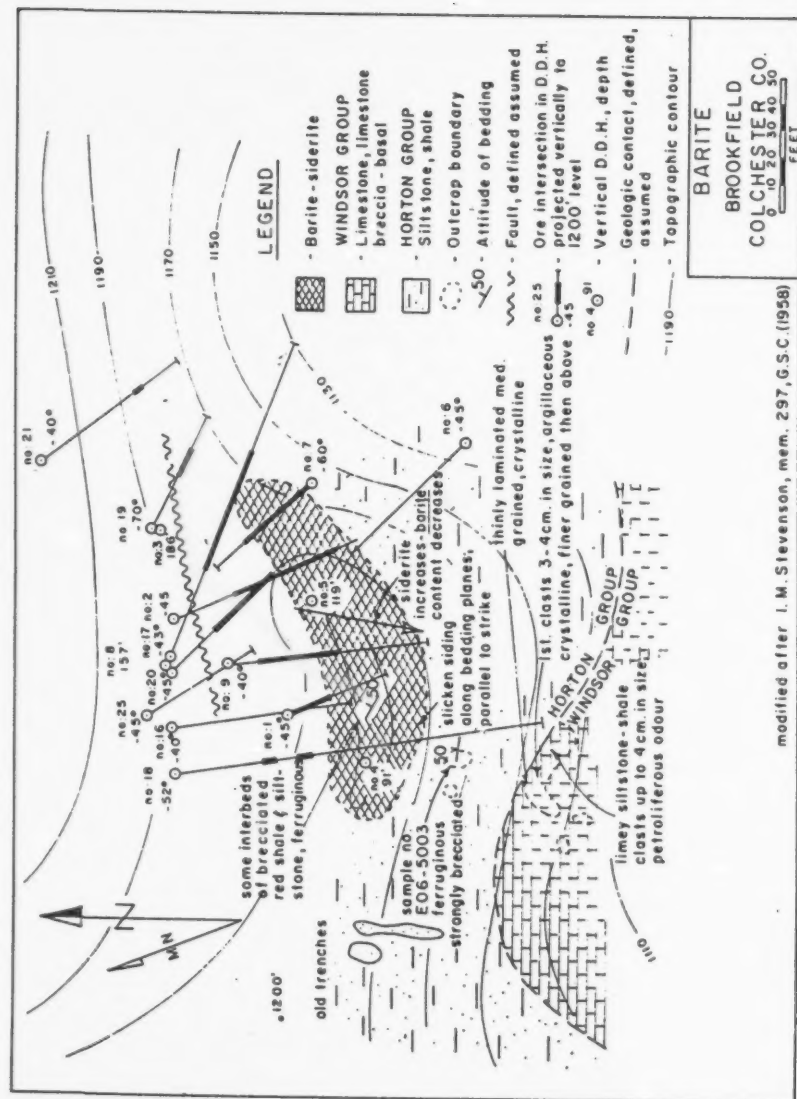


FIGURE 13

NSDME



sulphide minerals, and is entirely within the Horton.

(b) Production Barite at Brookfield was first mentioned in 1868 by J. W. Dawson and again in 1892 by Fletcher. Since 1944 when it was first developed, there have been mapping programs, gravity and resistivity surveys, trenching, milling tests, and at least 40 diamond-drill holes totalling 2888 metres in length. In 1951, plans for mining were begun and a concentrator plant constructed; however, this was an unsuccessful operation. In late 1983, in response to an increased demand for locally derived, drilling-grade barite, a Bendelari jig was installed at the mine. This operation produced approximately 5000 tonnes in each of the next two years for the offshore market. At the present time, the deposit is the primary source of pharmaceutical-grade barite for the Nystone Chemicals Ltd. mill in Debert, N.S.

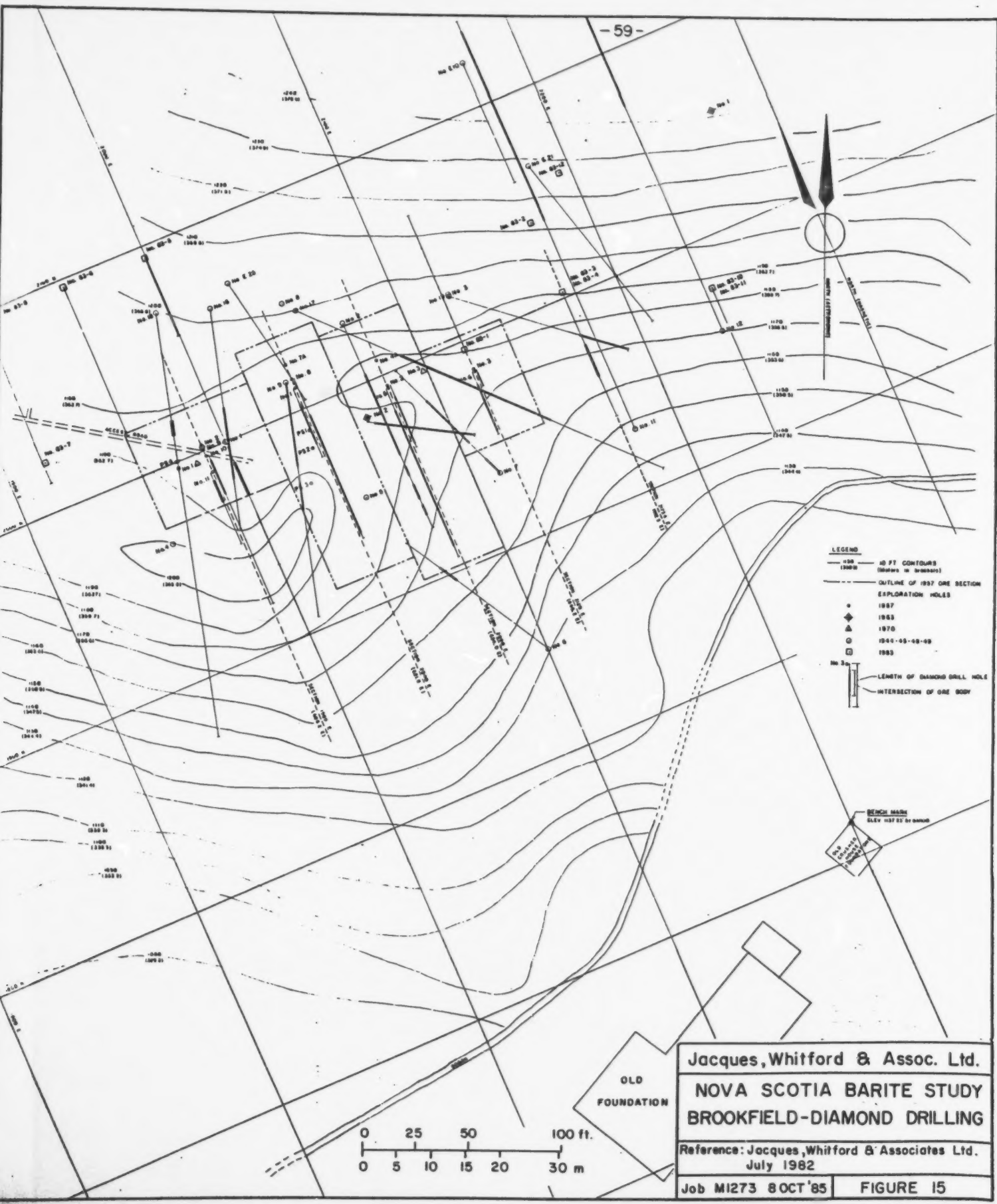
The deposit is currently being mined by an open-pit operation using some blasting and a D7 bulldozer on 3-metre benches (Figure 17). A front-end loader (4 m³ capacity) moves the broken ore from the face to a mobile crusher near the pit area. The ore is crushed to 1.3 cm and loaded on conventional 14-tonne end-dump trucks. These trucks require 2 hours per trip to haul the ore 28 km to the mill at Debert where it is stockpiled. The mining operation is carried on seasonally only: sufficient ore is stockpiled in the spring and summer for year-round milling operations.

The ore stockpiled at the mine (grading 30 to 35% BaSO₄), is fed into three cells of the Bendelari jig with a front-end loader at the rate of 18.2 tonnes per hour. This upgrades the ore to 80% BaSO₄ at a rate of 5.8 tonnes per hour. Hutch material grading 50% and tailings grading 25% BaSO₄ are produced at a rate of 12.4 tonnes per hour. The barite recovery from this operation is approximately 60%.

The products from the jig are stockpiled on site prior to shipment to the drill-mud customer, and the hatched material is sent to the mill at Debert. A settling pond was established to permit storage of tailings and to allow for a closed water circuit.

Raw barite ore, whether the crushed 16 to 19 mm size at 30 to 35% BaSO₄ or the hatched 3 mm material at 45 to 50% BaSO₄, is stockpiled at the mill and fed to the hopper at the rate of 2.5 to 3.0 tonnes per hour by a front-end loader during summer operations and from a storage silo in winter (Figure 18). The ore is ground wet in a rod mill equipped with a -48 mesh trommel screen. Primary beneficiation is carried out on two 1.2 x 3.7 m Wilfley tables which produce a concentrate containing 80% barite, 15% acid-soluble material (mainly siderite), 5% shales, and 1 to 2% silica. The table concentrate is then fed to a high-intensity, wet magnetic separator which reduces the acid-soluble fraction to 2% at a





LEGEND

40 FT. CONTOURS
(See map or brochure)

OUTLINE OF 1957 ORE SECTION

EXPLORATION HOLES

• 1957
♦ 1963
△ 1970
○ 1944-45-46-48
□ 1983

— LENGTH OF DIAMOND DRILL HOLE
— INTERSECTION OF ORE BODY

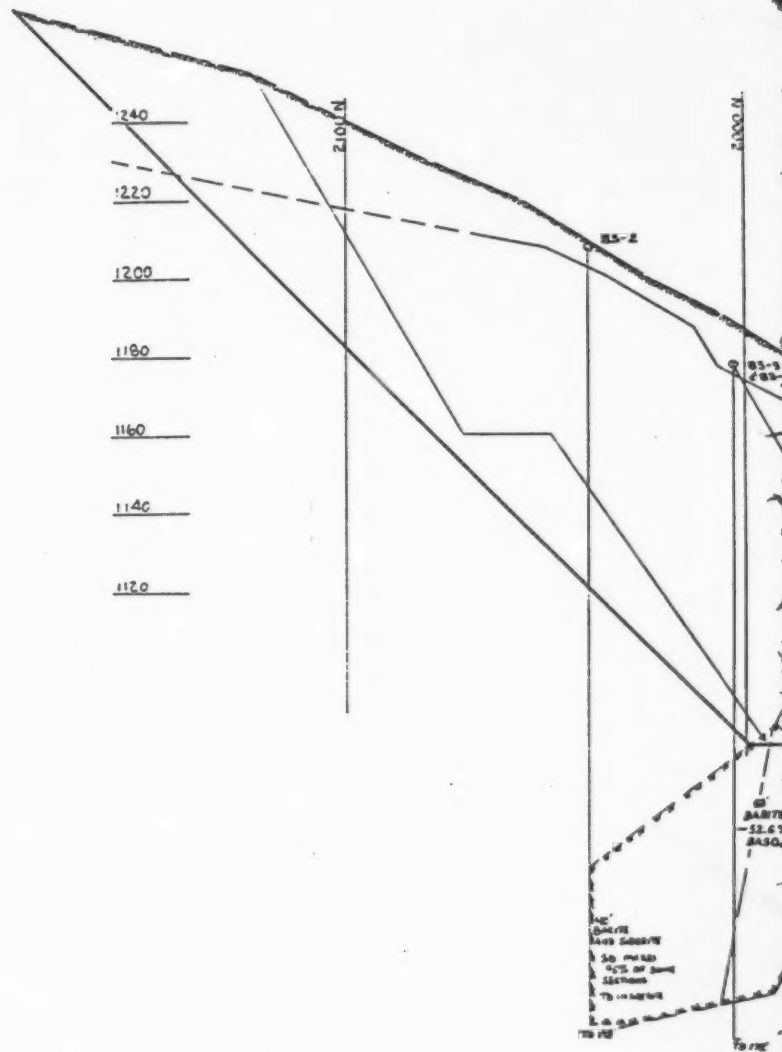
Jacques, Whitford & Assoc. Ltd.

**NOVA SCOTIA BARITE STUDY
BROOKFIELD-DIAMOND DRILLING**

Reference: Jacques, Whitford & Associates Ltd.
July 1982

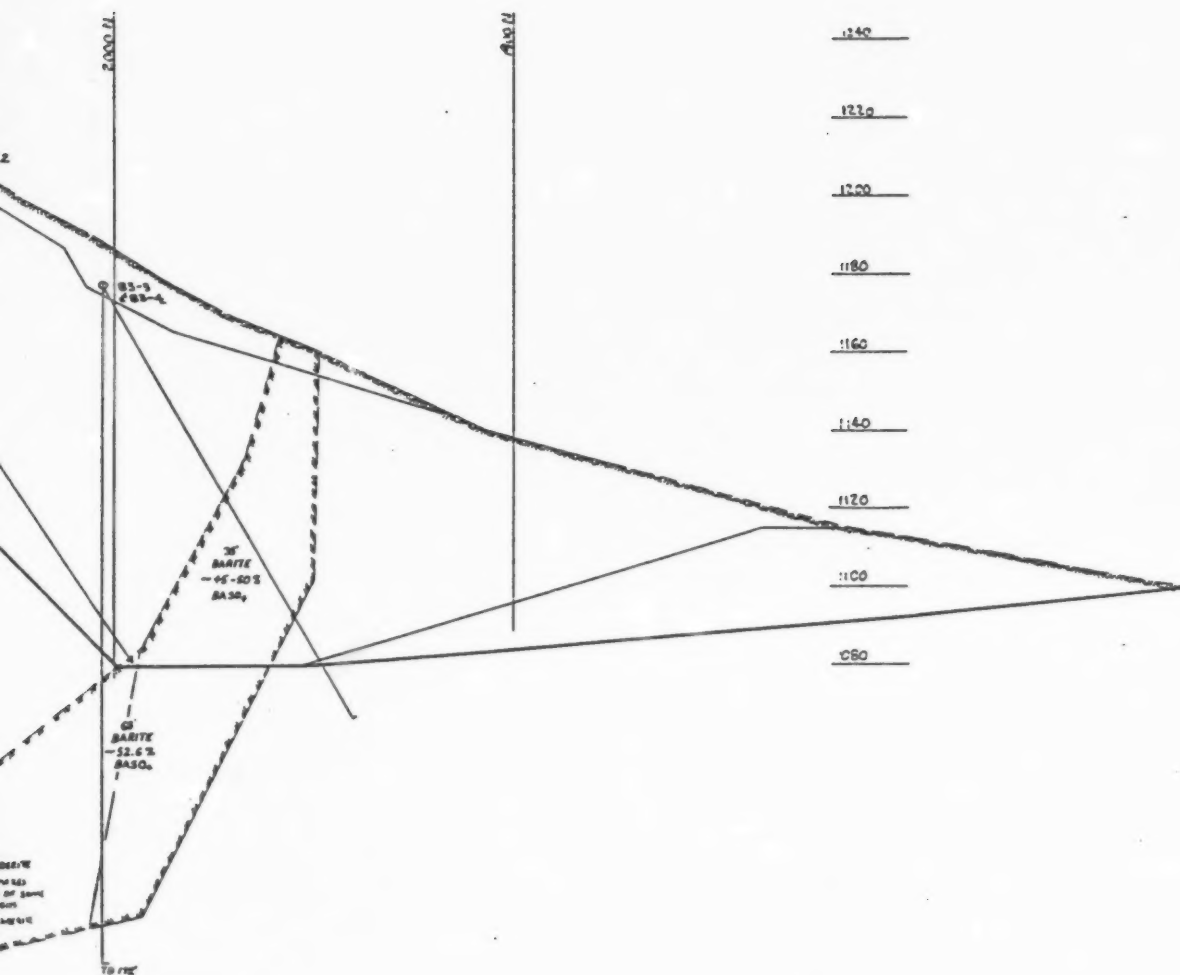
Job M1273 8 OCT '85

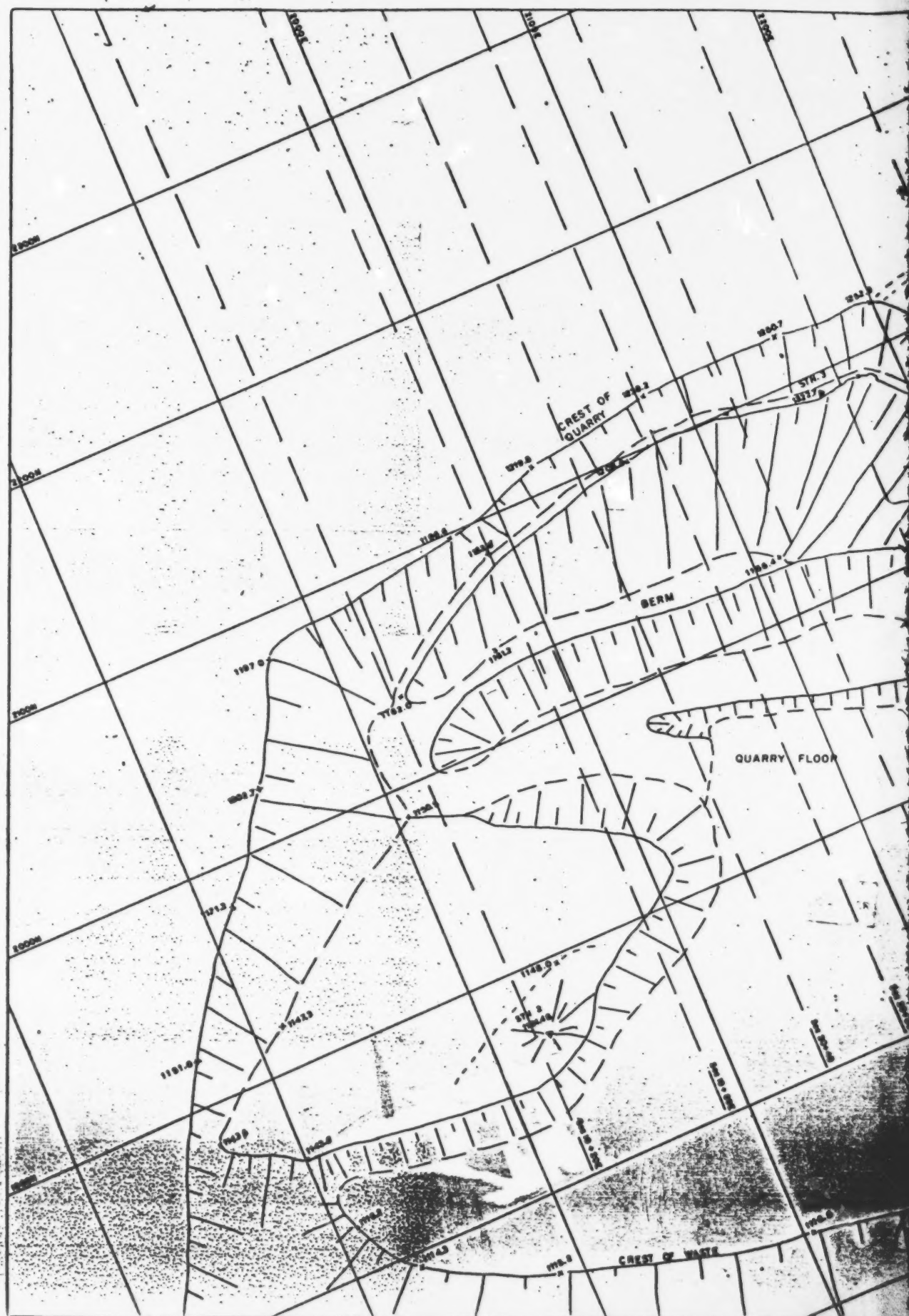
FIGURE 15



LEGEND:

- Original Surface Topography
- Barite Ore Zone
- Pit Outline, Nov. '83
- Ultimate Pit Boundary





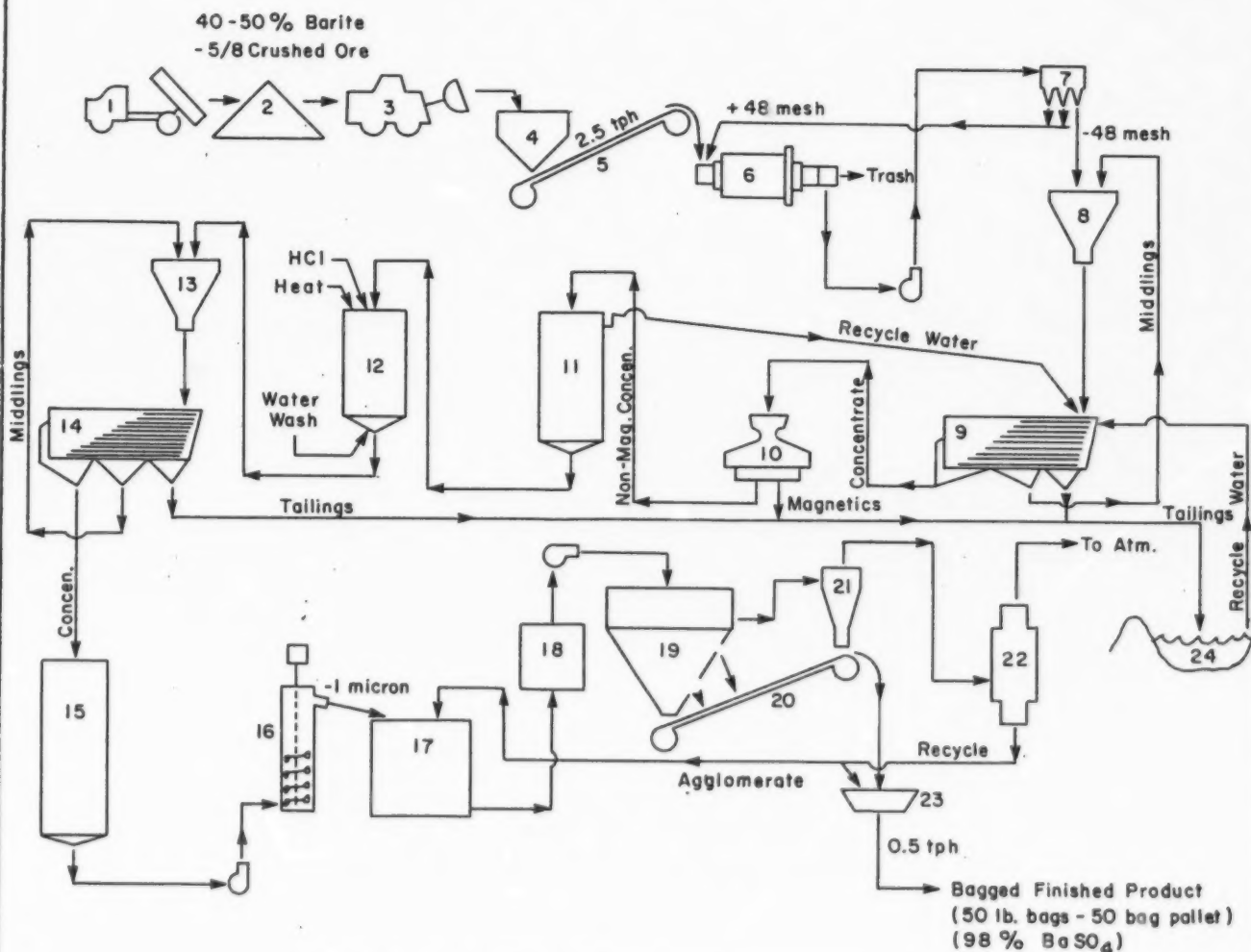


LEGEND:

- CREST OF SLOPE
- - - TOE OF SLOPE

Jacques Whitford & Assoc. Ltd.	
NOVA SCOTIA BARITE STUDY	
BROOKFIELD QUARRY	
Reference: N.S. Dept. of Mines & Energy January 1985	
Job M1273 8 OCT'85	FIGURE 17

NYSTONE CHEMICALS PHARMACEUTICAL BARITE PROCESSING FLOWSHEET



Id. No.	Quantity	Description of Equipment	Size
1		Rear End Dump Trucks	
2		Stockpile	
3		Front End Loader	
4		Feed Bin	
5		No. 1 Conveyor	
6		Rod Mill	3'x6'
7		Constriction Plate Classifier	
8		Feed Bin	
9	2	Shaking Tables	
10		Wet Magnetic Separator	
11		Surge Bin (Hot)	
12	3	Leach Tanks (Batch)	14 tonnes
13		Feed Bin	
14		Shaking Tables	
15	8	Surge Storage Bins	55 tonnes
16	3	Attrition Grinding Mills	
17	3	Slurry Holding Tanks	15 tonnes
18		Feed Tank	4 tonnes
19		Spray Dryer (Propane Fired)	14 ft diam.
20		No. 2 Conveyor	
21		Dust Cyclone	
22		Wet Scrubber	
23		Finish Screen	
24		Tailing Pond	

recovery of 90 to 95%. The concentrate is further treated in a vat of hot hydrochloric acid to leach the remaining soluble material. After washing to neutrality, the residue is fed to a 1.2 x 3.7 m Dyster single-deck shaking table. The cleaned material, now 98% BaSO_4 , is stored in a surge storage tank for attrition grinding.

Attrition grinding is accomplished in two steps by three custom-designed paddle mills which consist of a 50-centimetre diameter vertical cylinder, 2.75 m high, containing agitation paddles on the shaft with the bottom one-third filled with ceramic 8 to 16 mesh grinding media. The finished product of -1 micron material is then pumped to a 4.3 m diameter Niro spray dryer maintained at 85°C. The dry product is collected and screened at 100 mesh to remove agglomerated fines and then packed in 22.7 kg bags for shipment.

Five estimates of the size of the deposit indicate that the orebody at Brookfield originally contained about 125,000 tonnes of ore (44.2% barite) or 55,000 tonnes of barite (Table 6). By the end of 1985 an estimated 89,000 tonnes of ore will have been mined, leaving about 36,000 tonnes for future mining (Table 7). Of the 29,000 tonnes of barite mined in 1984, 3672 tonnes were sold as drilling mud (80% BaSO_4) and 418 tonnes were sold as pharmaceutical-grade barite. In 1985, at least 24,500 tonnes of ore will be needed to meet the demands of both drilling mud and the Debert plant. However, in future years no further drilling mud is planned and only 7364 tonnes of ore will be required annually to feed the Debert plant.

2. Walton Mine

The Walton open pit and underground mine is located near Walton, on the southern shore of Minas Basin, Hants County, N.S. (Figure 19). The operations have been inactive since 1978.

(a) Geology The Walton barite-sulphide orebody is located in a dilatant zone created by folding and faulting of Lower Carboniferous limestones, shales, sandstones and evaporite sequences. Barite has replaced the Macumber and Pembroke Formation limestones of Lowermost Windsor Group where they conformably lie on Cheverie clastic sedimentary rocks of the uppermost Horton Group (Figure 20). The Pembroke Formation is overlain by a thick section of cavernous gypsum, anhydrite and carbonaceous shale.

These Lower Carboniferous strata generally strike northeasterly and dip southeasterly but in the vicinity of the mine, have been folded into an S-fold and cut by several major east-west trending faults (Figure 21). The barite orebody, with grades averaging 90% BaSO_4 , is pipe-shaped and occurs at

TABLE 6
ESTIMATES OF ORE RESERVES

<u>Estimated by</u>	<u>Depth</u> (m)	<u>Ore Reserves</u> (tonnes)	<u>Grade</u> (%)	<u>Barite</u> (tonnes)
Maritime Barytes 1949	320	106,000	74.36	78,900
Magnet Core Barium Corp'n 1957	?	109,600	50.37	55,200
Magstone Dev. Inc. 1978	?	105,000	50.0	52,500
Jacques Whitford Assoc. 1984	330	125,000	44.2	55,000
N. S. D. M. E. 1985	330	119,000	50.0	59,500

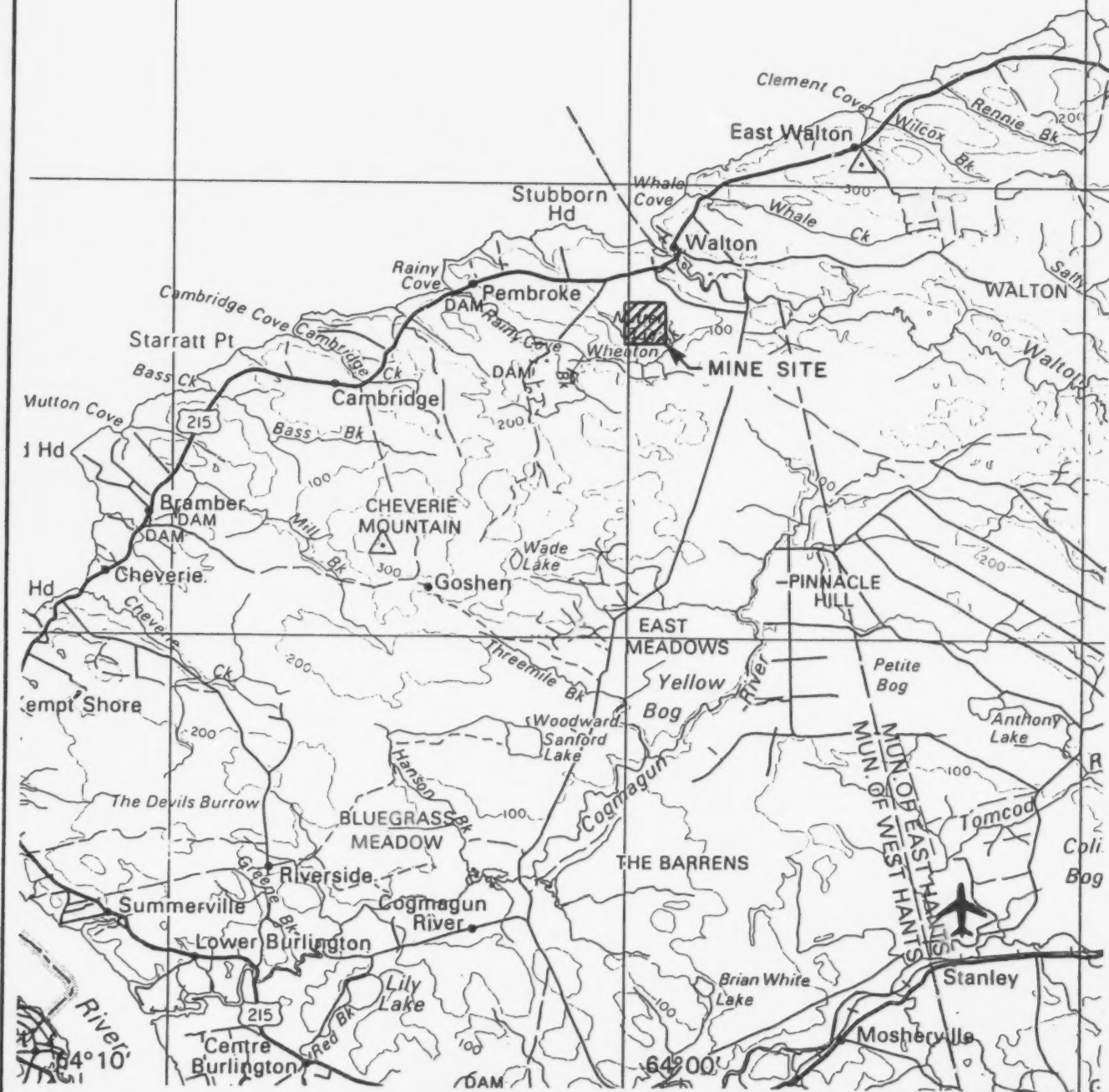
TABLE 7
ESTIMATE OF REMAINING ORE RESERVES

Estimate of Ore Reserves	125,000 tonnes
Mined to Oct, 1983	23,500 tonnes
Mined 1983-1984	29,100
To be mined 1985	36,400

Total Mined	89,000

Remaining Ore	<u>36,000</u> tonnes

MINAS BASIN



LOCATION MAP OF
WALTON MINE SITE

Scale:
1: 125,000

FIGURE 19

Date:
9/10/85

Dwn. By:
V.A.H.

Appd:

WA
JACQUES V. WHITFORD
B ASSOC. LTD.

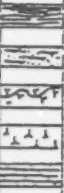
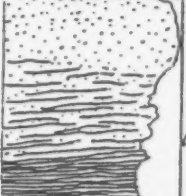
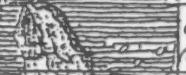
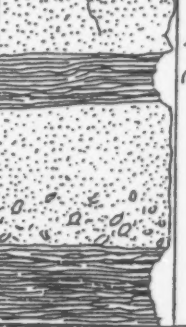
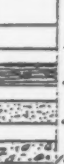
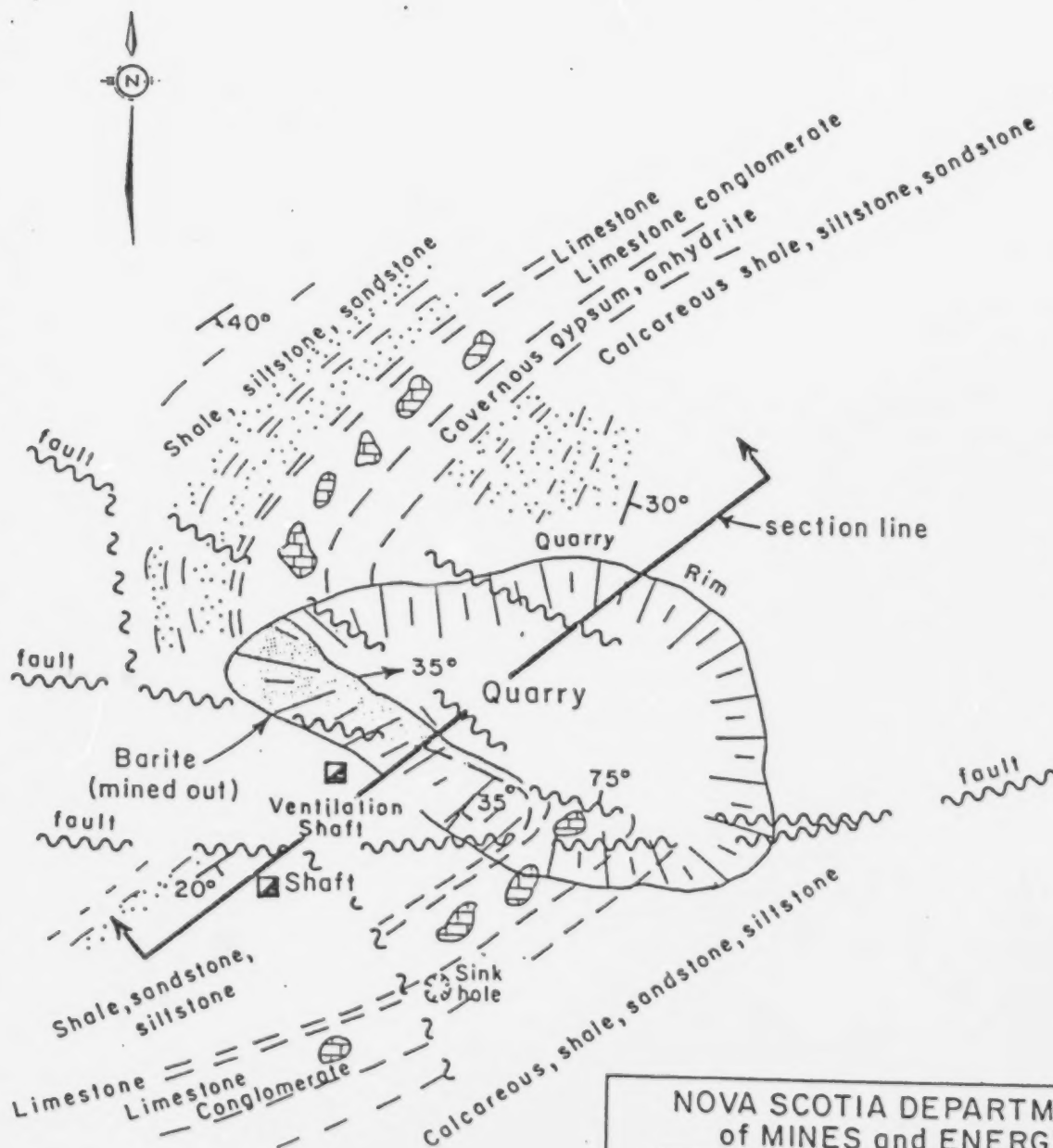
	FORMATION	STRATIGRAPHY OF ROCK IDENTIFY- ING PROFILE	THICKNESS OF FORMATION	KEY	LITHOLOGY	ROCK QUALITY
WINDSOR GROUP	UNDIVIDED		1500' (457m)		MARINE SHALE SILTSTONE GYPSUM ANHYDRITE LIMESTONE	
	TENNYCAPE		600' (182m)		RED SILTSTONE SANDSTONE SHALE	
	EVAPORITES		125' (38m)		GYPSUM ANHYDRITE	POOR TO FAIR SOLUBLE
	PEMBROKE		0-100' (0-30m)		LIMESTONE BARITE-SULPHIDES	POOR WATER CONDUIT
	MACUMBER		0-25'		MARINE LIMESTONE BARITE-SULPHIDES	POOR WATER CONDUIT
HORTON GROUP	CHEVERIE		1500' (457m)		ARKOSE SHALE SANDSTONE MICROCONGLOMERATE	GOOD
	HORTON BLUFF				SHALE, SANDSTONE LIMESTONE	GOOD

FIGURE 20: Geology and Rock Quality of Walton Area

NSDME



NOVA SCOTIA DEPARTMENT
of MINES and ENERGY

WALTON MINE

SURFACE GEOLOGY

0 500
feet

FIGURE 21

the intersection of the fold and the faults (Figure 22). Several smaller, sulphide bodies, mainly lenses and irregular masses, occur within the barite ore zones.

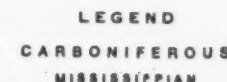
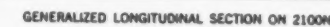
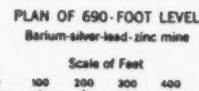
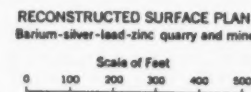
The quality of the rocks from a mining point of view is generally poor. The clastic rocks (sandstones, shales, siltstones and mudstones) cannot take high pressure on alternating wetting/drying conditions without deterioration. The caverns in the gypsum are often filled with mud slurries and may be interconnected even to sinkholes reaching the surface and extending to depths below 300 m. The brecciation of the ground by faulting, the friable nature of the clastic rocks, and the numerous conduits in the evaporite sequences have all led to unreliable mining conditions.

(b) Production The Walton open pit, at first owned by Canadian Industrial Minerals Ltd., began operating in 1940 by providing drilling-grade barite for the petroleum industry. In 1955 the operation was sold to Magnet Cove Barium Corporation, a division of Dresser Industries Inc. Because the pit had reached its maximum depth of 107 m, a shaft was sunk in 1956 for underground mining which began at the 160 m level. In 1959, with the ore exhausted from the open pit, production came only from the underground workings which were developed on several levels to the 500 m level.

A major inrush of mud and water in 1970 flooded the workings below the 375 m level. The mine was dewatered and production resumed. A second major inrush of mud flooded the mine in 1971 and the decision was made to abandon the workings below the 315 m level and retreat from the mine, extracting all ore between the 315 m level and the bottom of the open pit (Figure 23). In early 1978, while attempting to mine the crown pillar between the bottom of the pit at 107 m and the top of the underground workings at the 160 m level, there was a third, sudden inrush of mud and water from the bottom of the open pit. This event led to the decision to abandon further underground operations at the mine.

Production of barite continued from a salvage operation at the mine waste dumps, but this was discontinued in late 1978. The company reclaimed the mine site, poured a concrete plug in the main shaft, and dismantled the concentrator and headframe. The mine had produced 4,339,352 tonnes of barite and 363,000 tonnes of Cu-Pb-Zn-Ag sulphide ore.

The barite ore was crushed and beneficiated at the mine-site plant before being trucked to storage and shipping facilities in Walton. The sulphide ore was milled in a flotation plant with a capacity of 114 tonnes per day, before also being trucked for storage in Walton. A scavenger circuit in the latter mill recovered about 727 tonnes of barite a month.



WINDSOR GROUP

NORTON CIRCLE

TENNYCAPE FORMATION
red sandy shale, siliceous,
calcareous sandstone and
conglomerate

Anhydrite, gypsum, calcareous
and gypsiferous shale

PENBROKE FORMATION: limestone conglomerate, limestone, minor shale (developed in vicinity of basin and

MACLEODER FORMATION
from limestone (quartzite)
in vicinity of Lewis and

CHEVERIE FORMATION: gray and red shales, siltstones, and sandstones

Measured birds Discriminated birds
 Symbols: plain, scalars, pairs, females, parents, only other, unknowns all last group first group

Discovered sulphate nearly gone 100.00

Foot Breaks half way 4.4 Foot outside 2 Building finished 1 Cement put in 2.2

To accompany GSC Bulletin 189 by R.W. Boyle

Reference: Geological Survey of Canada
1970

Job MI273	8 OCT '85	FIGURE 22
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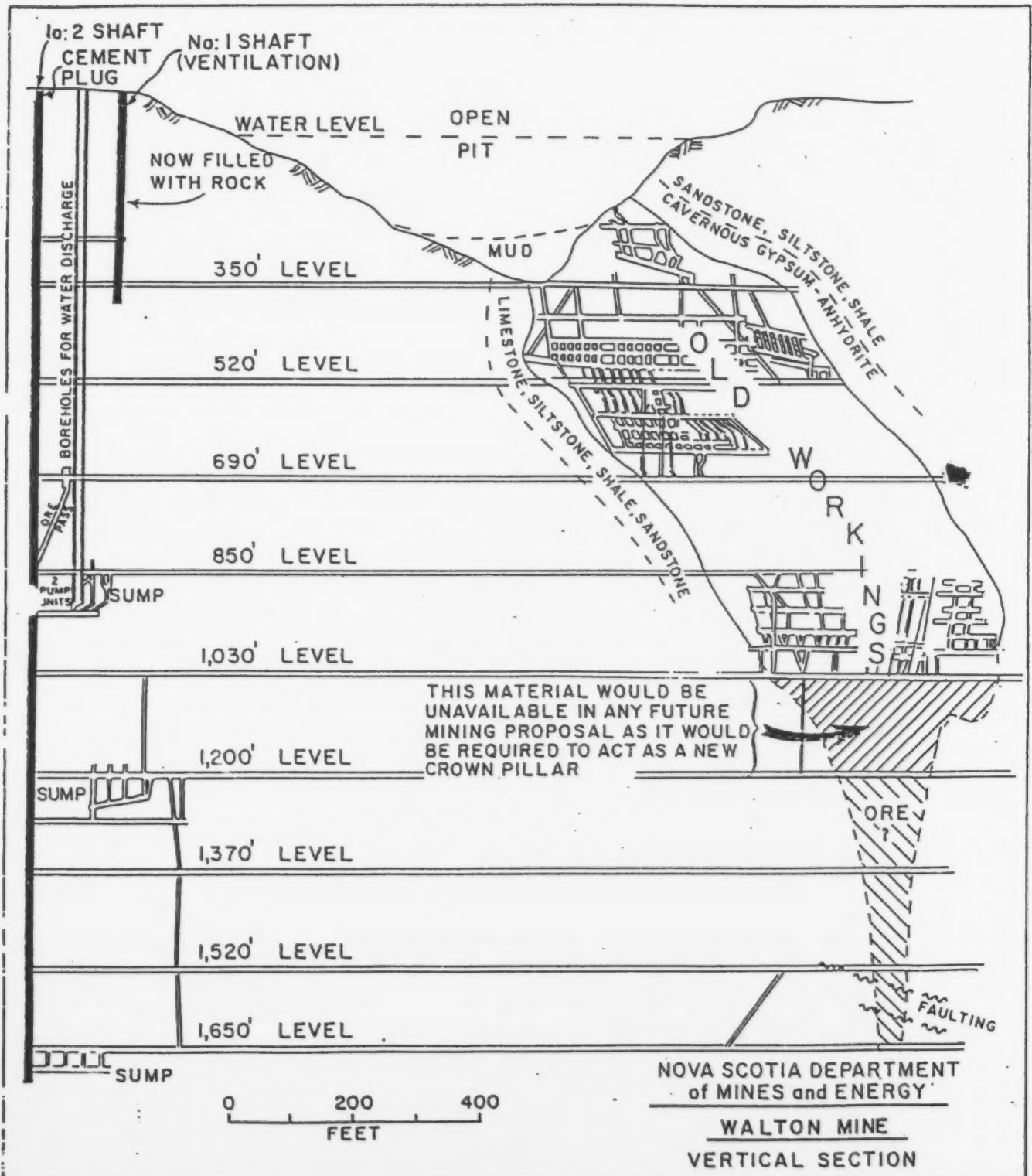


FIGURE 23

The concentrate shipped from the Walton mill consisted of barite and two base-metal products, a primary Pb-Cu-Ag concentrate and a secondary Zn-Ag concentrate. The bagged barite was shipped mainly to Trinidad and Venezuela for use in the oil-drilling industry, while the sulphide concentrates were shipped to smelters in Texas, Germany and England.

Since the closing of the mine, the mineral rights have been acquired by other interests, although Magcobar Drilling Fluid Services Ltd., a division of Dresser Canada Ltd. retained the surface rights. Magcobar has recently applied for a licence to recover barite from the surface dumps at the mine site. The operation is expected to produce 15,000 tonnes of drilling-grade barite per year, based on a two-shift per day, nine-month per year operation. The dumps are estimated to contain at least 650,000 m³ of material which can be processed to produce at least 90,000 tonnes of barite (5% extraction). The project will employ a total of 26 people and is expected to last at least six years. The process will be a gravity separation of the heavy barite from the lighter limestone, siltstone and mud, using water from the open pit, which is presently flooded (Figure 24). The waste rock would be returned to the open pit where the solids would settle out and the water reused.

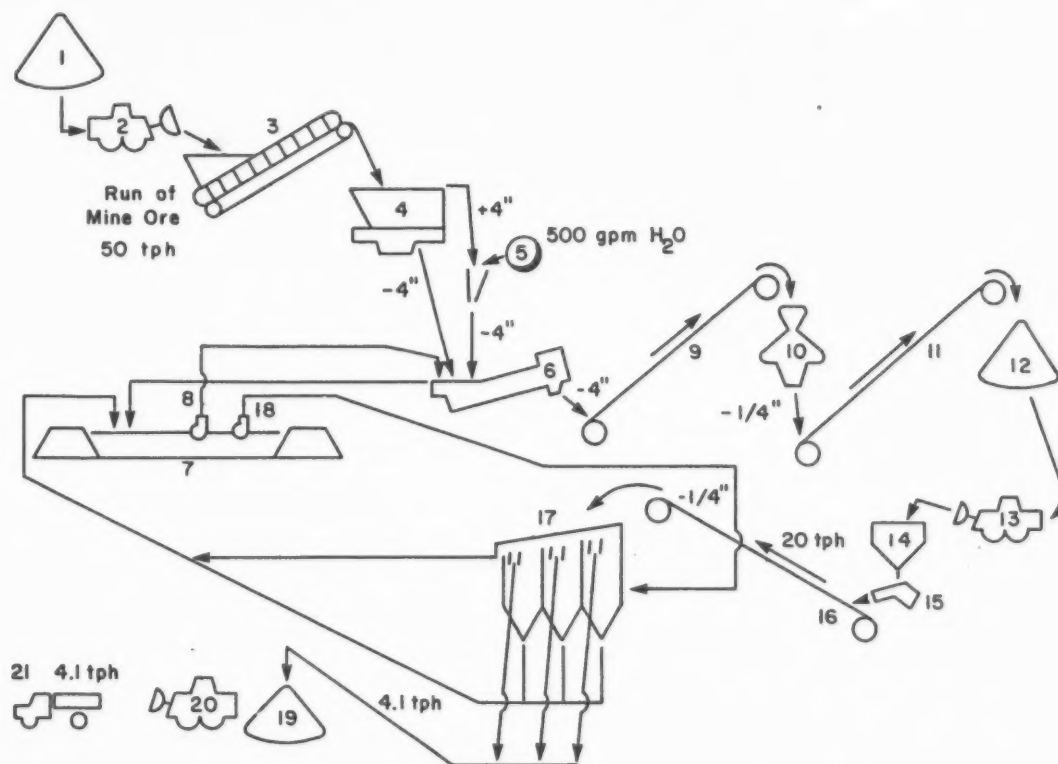
There is also an estimated 900,000 tonnes of barite and 30,000 tonnes of sulphide remaining between the 315 m level and the 500 m level (Table 8). Of this, a minimum of 545,000 tonnes of barite and 7000 tonnes of sulphide would have to remain in place to provide a crown pillar between the old workings (above the 515 m level) and any new areas that might conceivably be mined below the 366 m level. If a new underground mine is ever established below these old workings, a portion of the material left in the crown pillar could be recovered later during retreat procedures from the mine. There is some potential for additional tonnages of barite and sulphides below the 500 m level and to the south of the present development drifts.

3. Bass River

The Bass River barite property is located about 3 km north of the small village of Upper Bass River, just off Highway 2 in Colchester County, N.S. (Figure 25). The barite deposit sits at the top of a steep embankment, and about 15 m above, and on the west side of a tributary of Bass River (Figure 26).

(a) Geology The deposit occurs in terrigenous clastic sedimentary rocks belonging to the Cumberland and/or Pictou Groups of Upper Carboniferous (Pennsylvanian) age and lying within the Cobequid Fault Complex. The barite is

WALTON MINE WASTE RECOVERY FLOWSHEET



No. Id. Quantity	Description of Equipment	Size
1	Stockpile	
2	Front end loader	
3	Apron feeder	42"x10'
4	Grizzly, 4"	4'x4'
5	Jaw crusher, 4"	15"x18"
6	Log washer	16"x24"
7	Tailings pond	
8	Flygt pump 500 gpm	6"
9	Belt conveyor	24"x50'
10	Cone crusher, 3/4"	1'
11	Belt conveyor	24"x50'
12	Stockpile	
13	Front end loader	
14	Hopper	10 ton
15	Feeder	24"x16'
16	Belt conveyor	24"x50'
17	2 Bendalari jigs	
18	Flygt pump 1200 gpm	6"
19	Concentrate stockpile	
20	Front end loader	
21	Rear end dump truck	

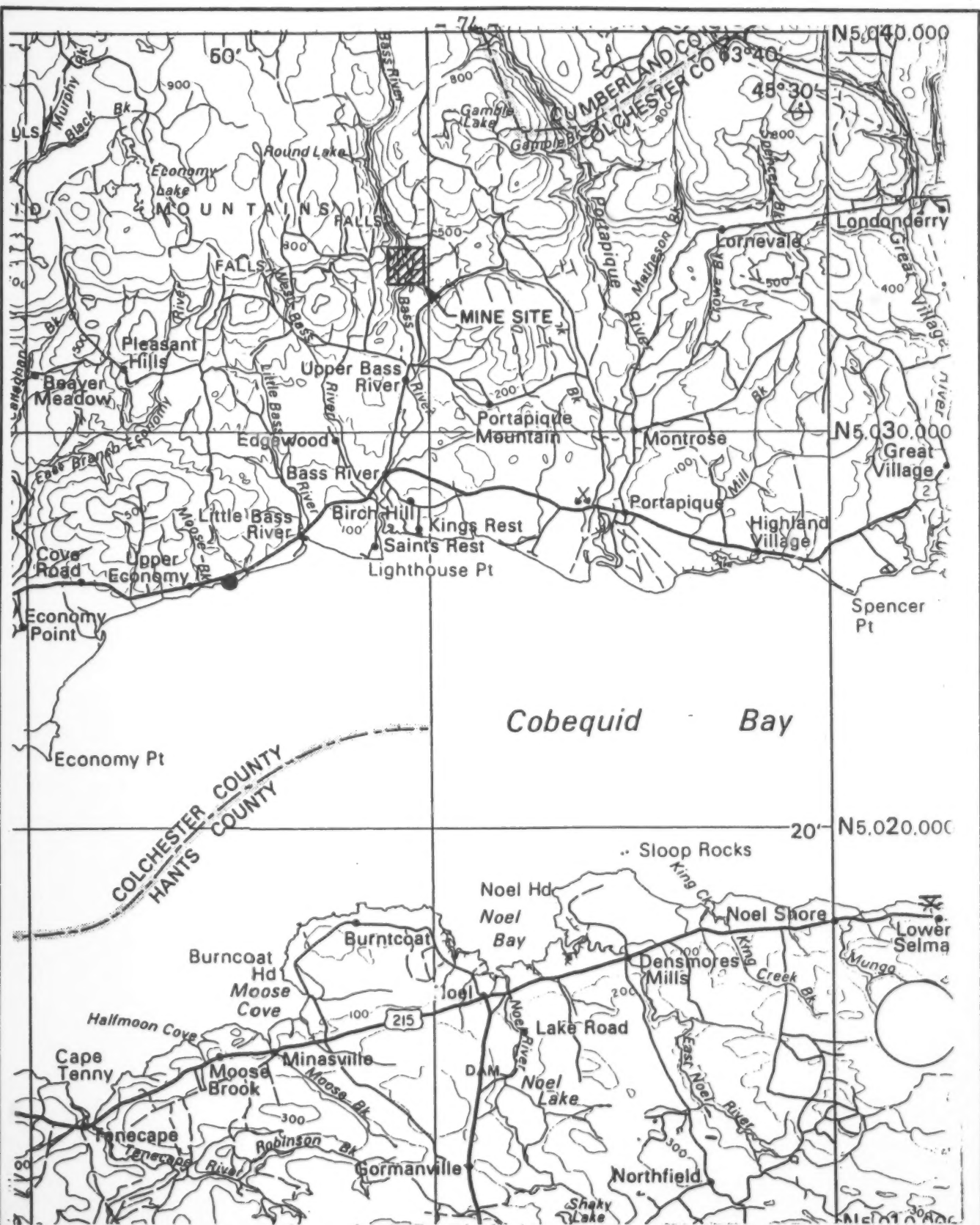
WALTON MINE, INSITU RESOURCES *

(TONNES)

<u>LEVEL</u>	<u>BARITE</u>	<u>SULPHIDE</u>
ABOVE 1030'	Ø	Ø
1030' - 1200'	545,000	7,000
1200' - 1370'	197,000	Ø
1370' - 1520'	114,000	Ø
1520' - 1650'	44,000	23,000
<u>TOTAL</u>	<u>900,000</u>	<u>30,000</u>

* THE INSITU RESOURCES DESIGNATION REFERS TO MINERALIZATION IN PLACE.

TABLE 8



LOCATION MAP OF BASS RIVER
MINE SITE

Scale:
1:125,000

FIGURE 25

Date:
9/10/85

Dwn. By:
V.A.H.

Appd:

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& ASSOC. LTD.

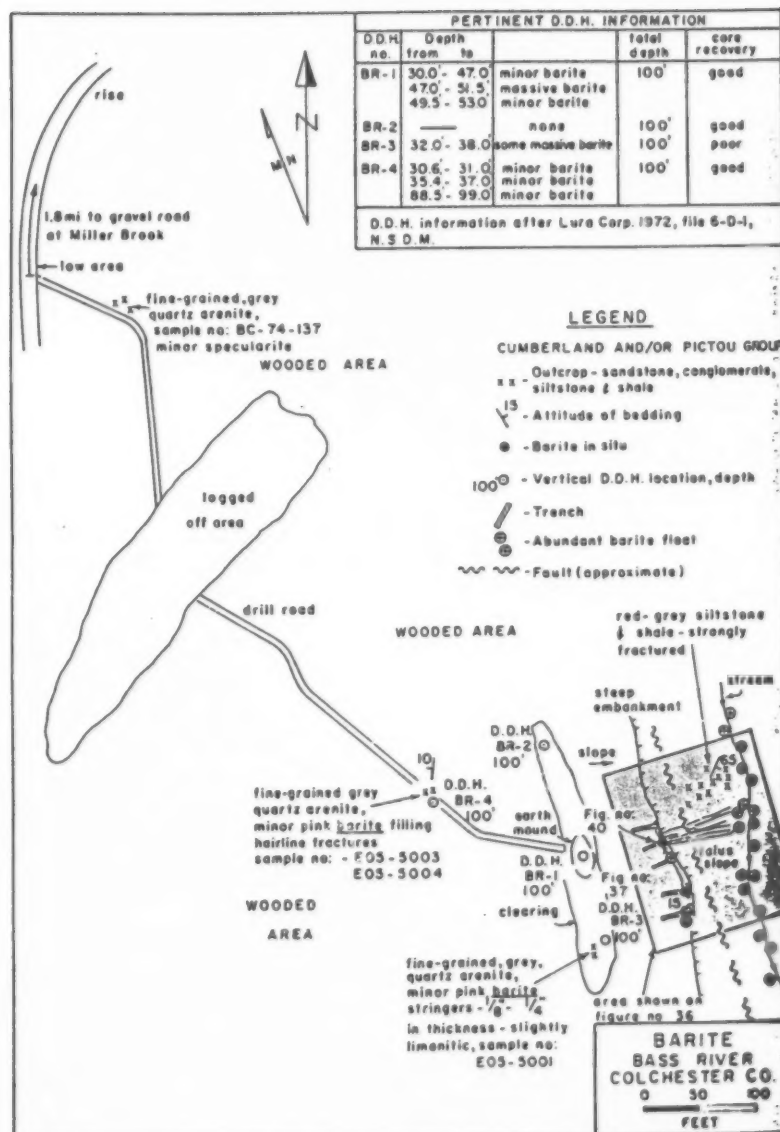


FIGURE 26

stratigraphically controlled, having preferentially replaced a 1.5 to 2.5 m bed of siltstone and fine-grained sandstone. The footwall rocks, which are exposed lower on the embankment, consist of a pebble conglomerate with a greenish mudstone matrix striking northerly and dipping gently westward. These rocks are cut off to the east (though west of the river) by a northerly striking, easterly dipping fault which offsets the Cobequid Fault (Figure 27). Although the deposit itself is overlain only by loose overburden, about 40 m to the west there are outcrops of a fine-grained quartz arenite containing 3 to 6 mm stringers of pink barite which may represent the hanging wall rocks.

The deposit generally consists of fine- to coarse-grained, creamy pink barite. The main bed in the deposit contains fine- to medium-grained barite showing a distinct layering parallel to the bedding in the footwall rocks. The layers or laminae are 3 to 6 mm thick and are separated by thin layers of fine silt and clay. Some of the barite has vugs; the smaller ones contain barite rosettes and are filled with fine silt. There is a gradational contact with the footwall beds where fine- to medium-grained barite is intimately associated with the conglomerate. The medium-grained barite shows a distinct bladed habit. Some of the barite, usually medium to coarse grained, forms nodular concretions up to 10 cm across. Minor amounts of barite occur as small (6 mm), tabular, transparent crystals in vugs.

(b) Production Barite was first discovered at Bass River in 1952-3 during surveys carried out by Gordon Minerals Ltd. In 1957 Magnet Cove Barium Corporation Ltd. dug a total of 47 m of trenches which revealed a barite bed about 2.4 m thick. Further trenching and a VLF electromagnetic survey by the Milnor Syndicate in 1971 indicated a minimum strike length of 61 m and a possible length of 762 m. Four drill holes of 30 m each were drilled the following year by IMC Drilling Mud Inc. but the results were discouraging. Additional drilling by Magcobar-Dresser in 1983 indicated in excess of 3000 tonnes of drilling-grade barite (Figure 28). About 700 tonnes of this were shipped in 1983-4 to the mill at Walton, N.S. Another 2816 tonnes were shipped in 1984-5 (unpublished sources). The property is presently dormant.

4. Lake Ainslie

The Lake Ainslie barite deposits are a series of barite-fluorite veins near the communities of Lake Ainslie and Trout River on the east side of Lake Ainslie, Inverness County, N.S. (Figure 29). The veins crop out over a narrow, north-south trending zone about 3 km long and 1 to 2 km east of the shore of the lake. Access to the properties can be made by several bush roads from Highway 395 which joins the Trans Canada Highway at Whycomagh.

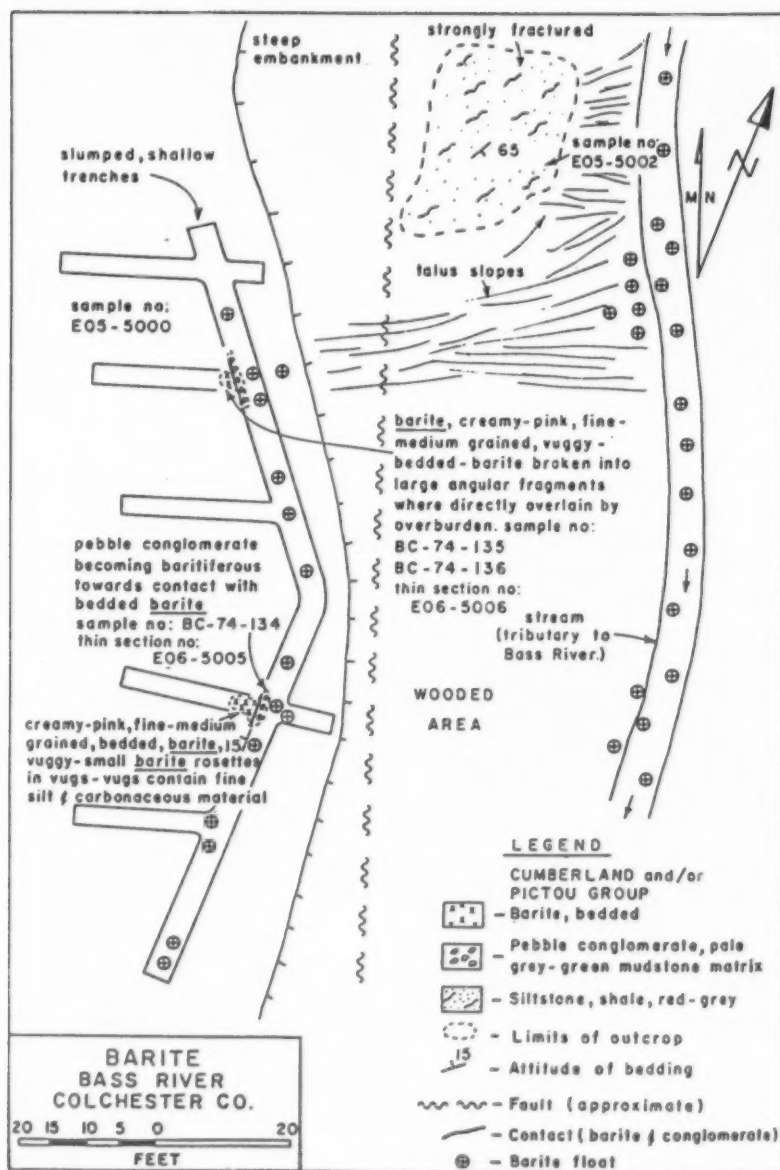
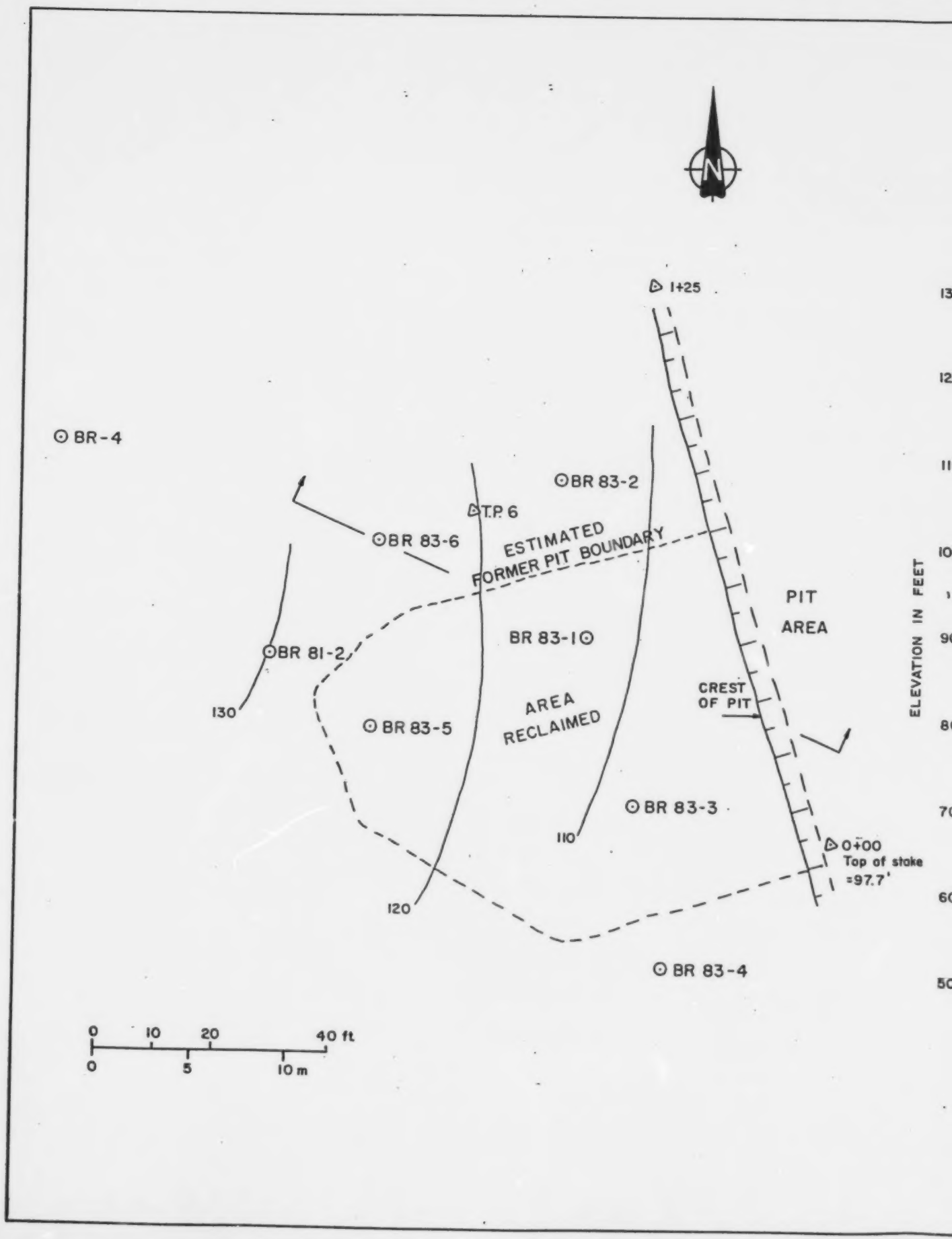
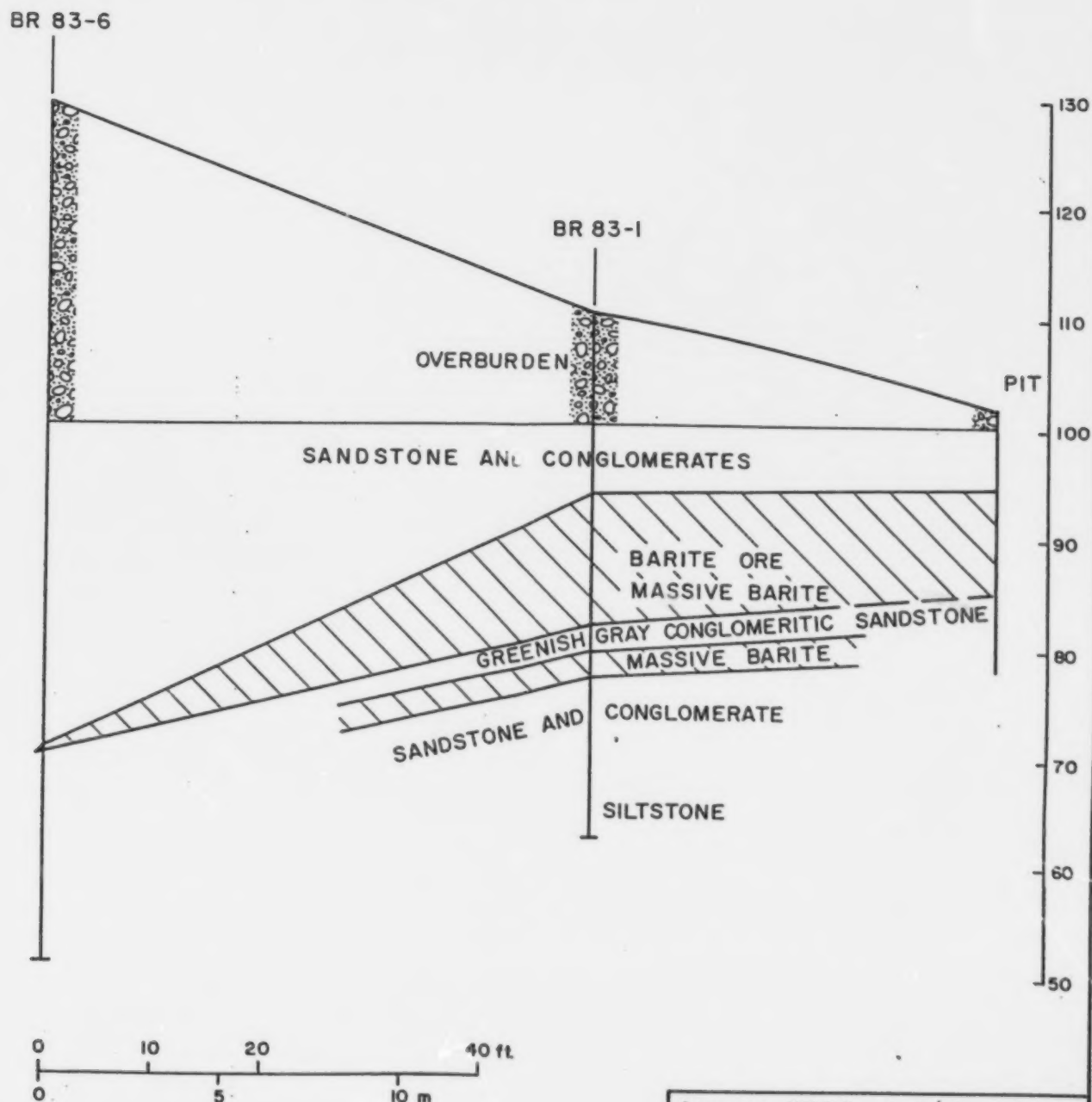


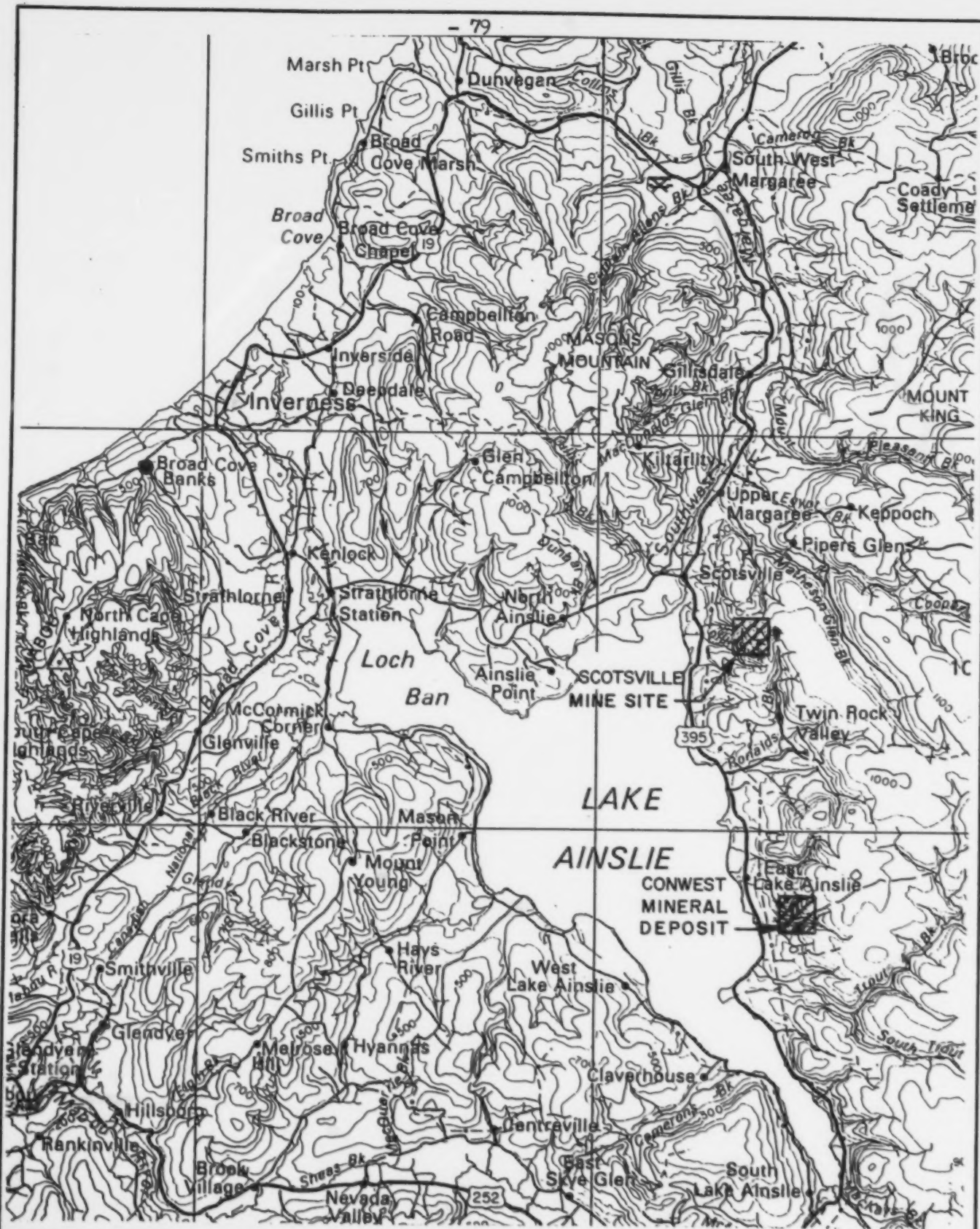
FIGURE 27

NSDME





Jacques, Whitford & Assoc. Ltd.	
NOVA SCOTIA BARITE STUDY	
BASS RIVER	
Reference: Magcobar, Dresser Industries Inc. 1983, 1984	
Job M1273 8 OCT '85	FIGURE 28



LOCATION MAP OF SCOTSVILLE MINE
SITE & LAKE AINSLIE DEPOSIT

Scale:

1:125,000

FIGURE 29

Date:

9/10/85

Own. By:

V.A.H.

Appd:

WA

JACQUES V. WHITFORD
& ASSOC. LTD.

(a) Geology The Lake Ainslie deposits are spatially related to an inlier, 4 to 5 km long and 1.5 to 2 km wide, which occupies the crest of a north-south trending anticline east of Lake Ainslie (Figure 30). The inlier, a window in Horton Group rocks, exposes George River Group metamorphic rocks of Precambrian age cut by granitic rocks of Devonian age in the central core area, and Lower Carboniferous Fisset Brook volcanic rocks around the margins.

The Fisset Brook Formation is the host for the vein deposits of this area. It consists of a basal sequence of conglomerates, quartz and lithic wackes, and an intermediate layer of andesitic flows with minor volcanic and non-volcanic sedimentary rocks. The upper part is composed of porous, grayish-orange to pinkish-orange, welded rhyolitic tuffs and assorted tuff-agglomerates. The rocks are massive to foliated with layers marked by their degree of welding.

The majority of the barite-fluorite veins occur in the Upper Fisset Brook Formation. All the veins are developed along prominent faults and subsidiary tension fractures and shears. The veins are located in four areas, mostly on topographic highs (Figure 30).

Bald Mountain Area The veins in the Bald Mountain area have been named the Campbell, MacMillan, D.J. MacDougall, and Moore veins (Figure 30). The Campbell vein occupies a fault zone which puts Horton Group sedimentary rocks against welded rhyolitic tuffs of the Fisset Brook Formation (Figure 31). Two adits, the northern one about 70 m long and the southern one about 140 m long, have been driven eastward to the vein which strikes 071° and dips vertically. The D.J. MacDougall vein, about 180 m northeast of the Campbell vein, also occupies a fault wholly in welded rhyolitic tuffs of the Fisset Brook Formation (Figure 32). A large open cut, an adit, and several vertical shafts have exposed a vein at least 1.4 m wide which strikes 100° and dips 65°S . The MacMillan vein, about 60 m southeast of the D.J. MacDougall vein, occupies a fault zone in welded rhyolitic tuffs (Figure 32). It is generally 6 to 12 m wide but may be as much as 15 m and strikes 070° , dipping 75°SE . The vein has been traced for 88 m along the surface and to 215 m depth by drilling. A long, wide open cut and, at the northeastern end, a 70° inclined shaft, 38 m long with drifts at the 15 m and 38 m depths have been used to explore the vein underground. The Moore vein, 290 m to the northeast, is only 4 m long by 2 m wide and has been explored by a 30-metre trench.

South Bald Hill The top of South Bald Hill, about 500 m south of Bald Mountain, is the site of the MacLean vein and several small veins on the northern flank. The vein occurs wholly in welded rhyolitic tuffs and has a maximum width of 1 m, a length of 70 m, and strikes 062° , dipping vertically. It has been explored by a few small pits and a short trench.

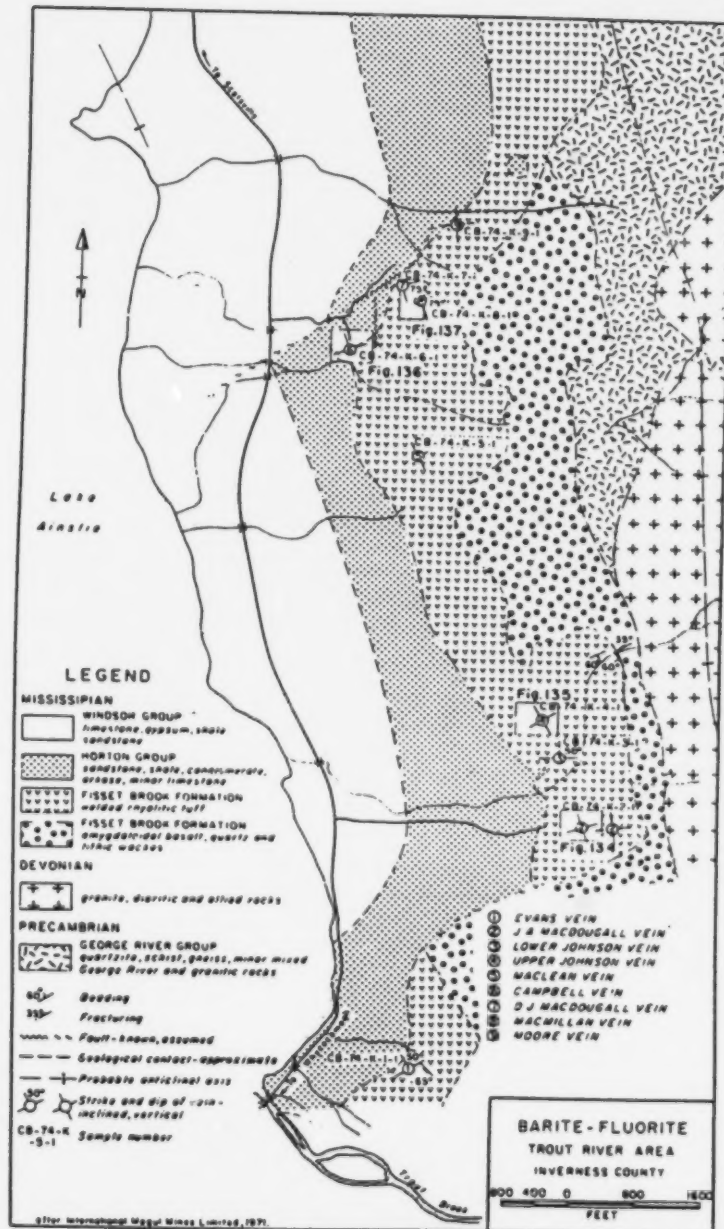


FIGURE 30

NSDME

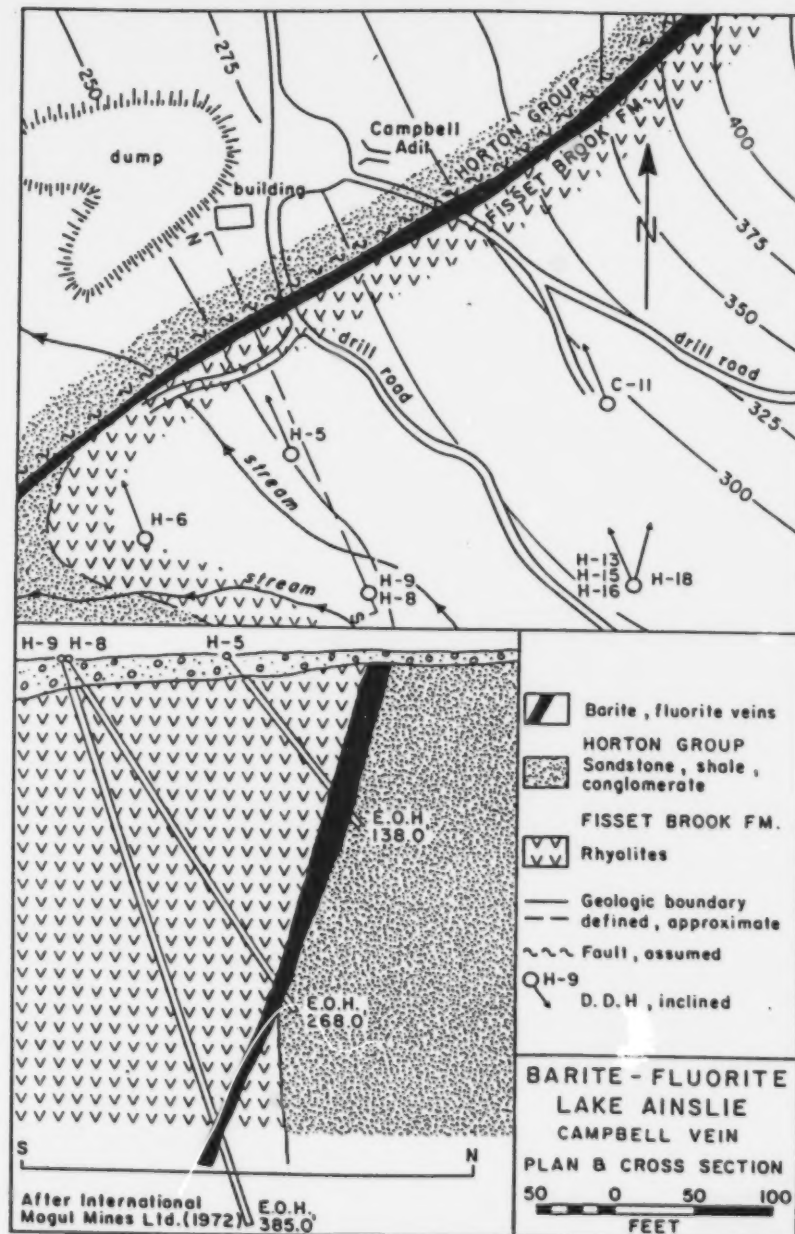
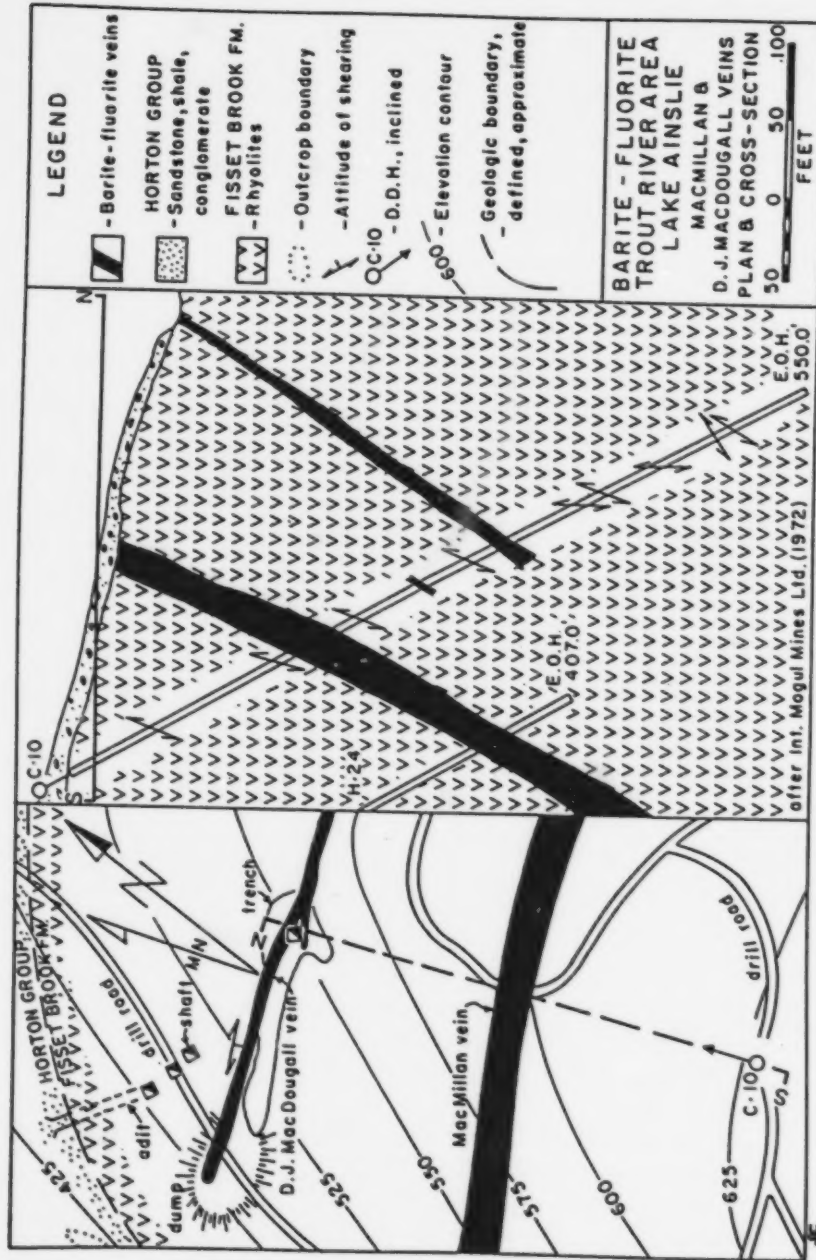


FIGURE 31

NSDME



NSDME

FIGURE 32

Johnson Hill The top of Johnson Hill, about 1.5 km south of Bald Mountain, is the site of the Upper and the Lower Johnson veins as well as several parallel veins. The Upper Johnson vein occupies a fault which cuts the welded rhyolitic tuffs of the Fisset Brook Formation and strikes 064°, dipping 85°N to vertical (Figure 33). It is over 122 m long and 1 to 3 m wide at the surface, and plunges westerly beneath Horton Group rocks. It is exposed at the surface by a 40-metre trench and several small pits, and at depth by a shaft near the southwestern end. The Lower Johnson vein is about 150 m further south. The vein fills an east-west fault zone cutting welded rhyolitic tuffs of the Fisset Brook Formation. Three adits, 2 of them connected by underground workings and stopes, show the vein to have a maximum width of 3 m and a dip of 64°N.

Johnson Flats The relatively subdued topography just south of Johnson Hill is the site of the J.A. MacDougall vein and a few minor veins. The J.A. MacDougall vein fills a fault zone in rhyolitic tuff which strikes 080° and dips 70°N to vertically (Figure 34). It is 43 m long and 2.7 m wide. There is a short adit.

All the veins contain barite and fluorite. The barite is white to creamy white to pink, usually massive, sometimes coarsely crystalline and may form rosettes. The fluorite is greenish to colourless to purplish and forms disseminations or less commonly granular aggregates but always more abundantly near the margins of the veins. Gangue minerals include minor calcite and trace amounts of manganiferous limonite, pyrite and chalcopryrite as well as wad in the rather abundant cavities.

(b) Production These veins have been known for over 90 years. During this time many explorers and developers have assessed and attempted to exploit these deposits, but to date no significant production of barite or fluorite from them has been achieved. International Mogul Mines Ltd. and Conwest Exploration Company Ltd. together have been assessing the Lake Ainslie deposits continuously since 1965. Exploration field programs were carried out during the 1965-6 and the 1971-2 periods. In more recent years considerable work has been devoted to metallurgical investigations and capital and operating cost studies. Chemical analyses of grab samples from these deposits are shown in Appendix 6.

The deposits at Bald Mountain and at Johnson Hill appear to have the most promising future because of the tonnages they contain. At least 47 diamond drill holes totalling over 8000 m have indicated that the Bald Mountain veins contain 2.5 million tonnes of 30% barite and 20% fluorite to a depth of 245 m. At least 19 diamond drill holes totalling over 2800 m have indicated that the Johnson Hill veins, particularly the Upper Johnson vein, contain 900,000

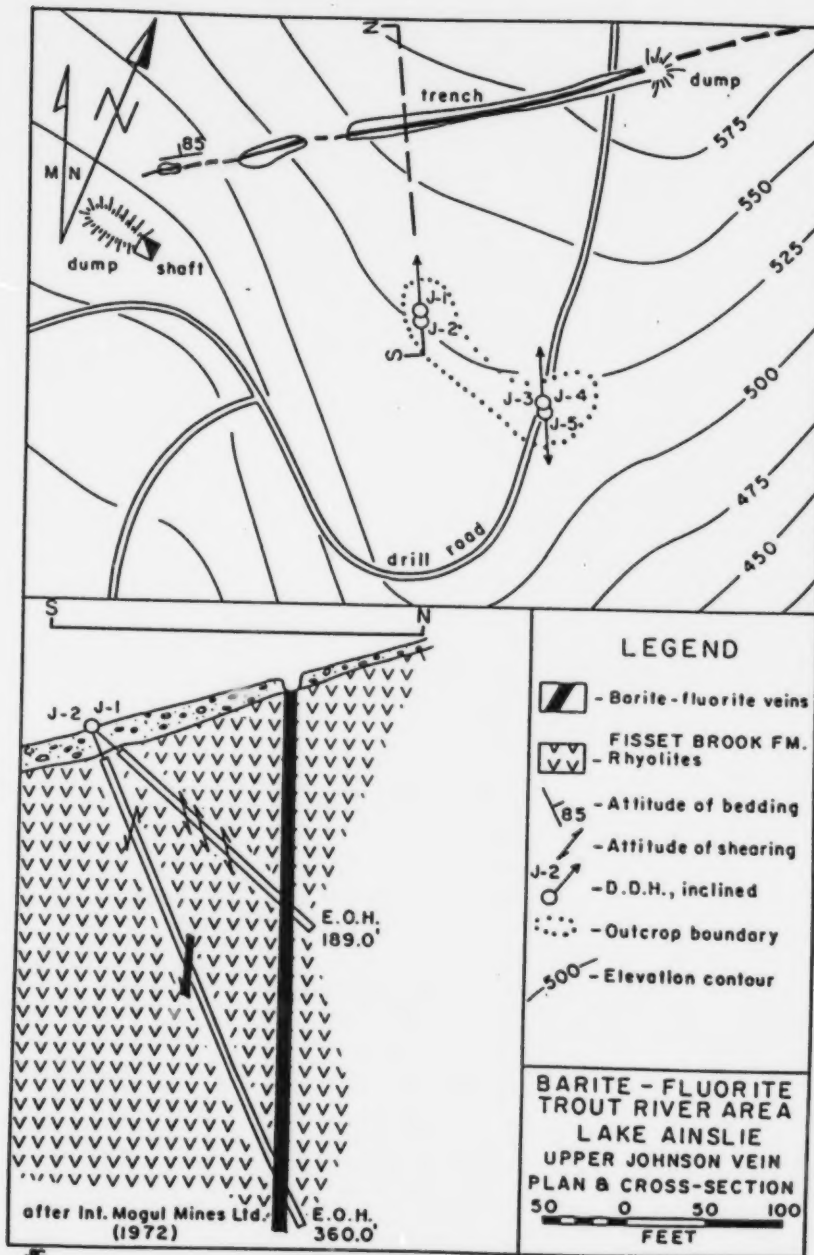


FIGURE 33

NSDME

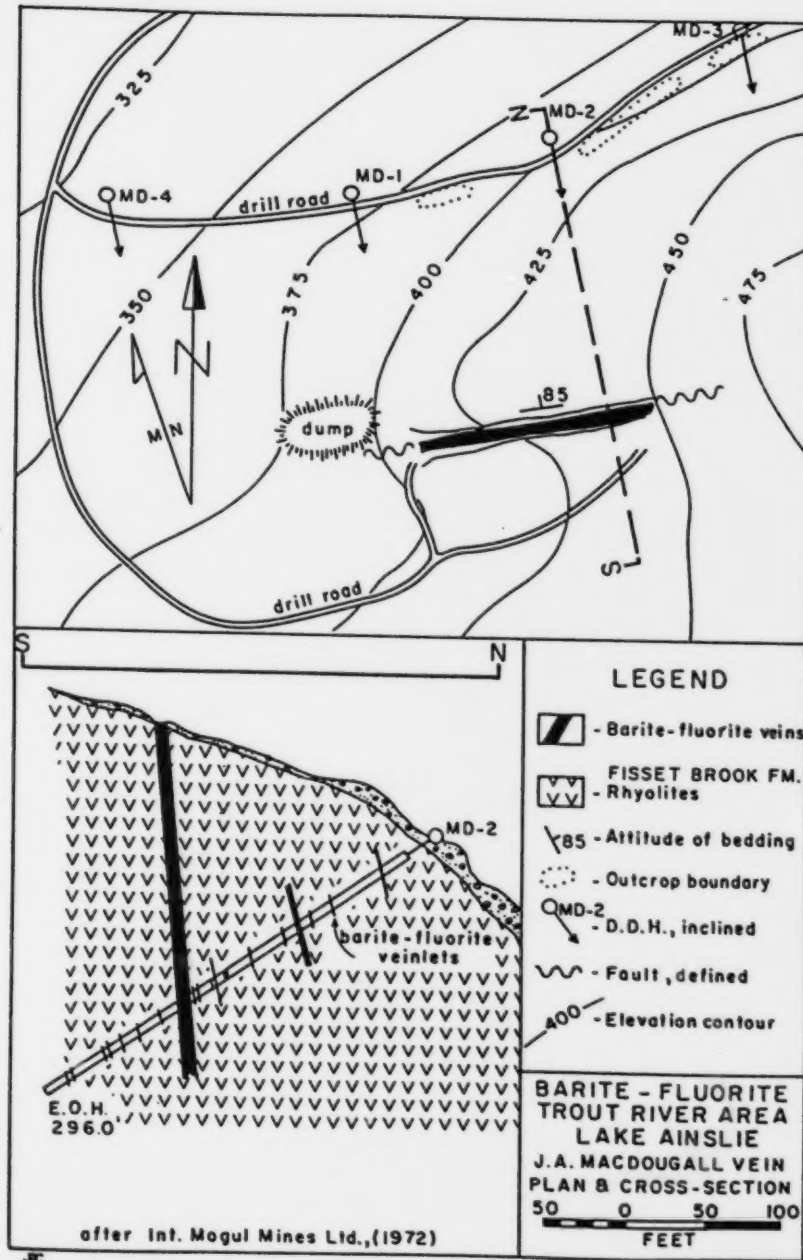


FIGURE 34

NSDME

tonnes of 48% barite and 17% fluorite to a depth of 215 m. Other drilling has indicated 326,000 tonnes of 38% barite and 9% fluorite in the J.A. MacDougall vein. A full recovery of the barite from these veins would produce 1.3 million tonnes of pure barite.

Various metallurgical processes have been tried for the Lake Ainslie barite-fluorite ores; these fall into two main approaches. First, a two-stage flotation system was devised, and bench-scale tests at a grind of 82% passing 325 mesh has indicated good barite grades (95%) and recoveries (90%), and reasonable fluorite grades (97%) and recoveries (85%). Pilot-plant investigations have confirmed the bench-scale tests for barite recoveries, but fluorite recoveries and concentrate quality was not satisfactory. The flotation process overall is rather costly with reagent and energy costs as the principal items.

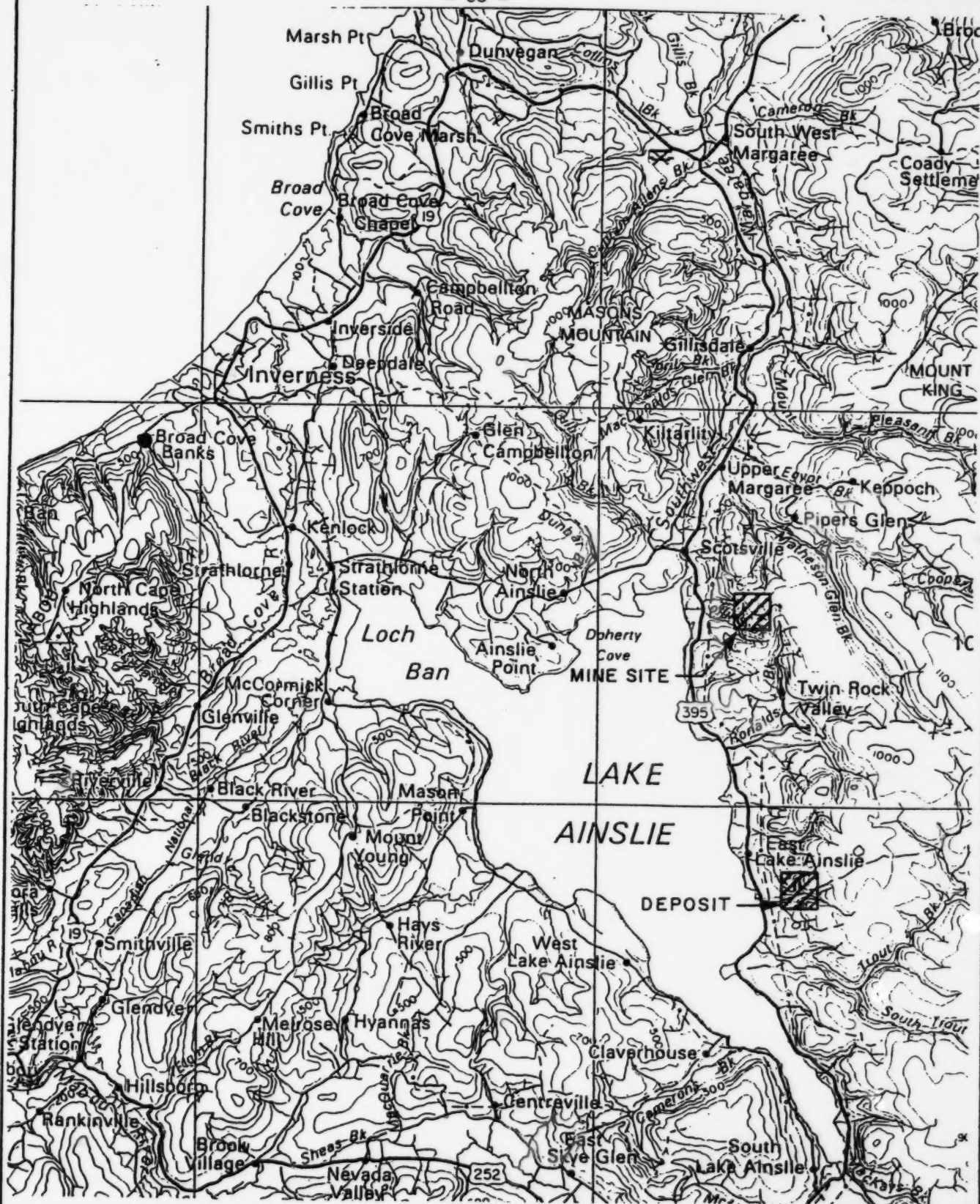
Secondly, gravity methods were investigated to produce a finished barite product and to reduce the barite grade in the feed to recover the balance in a flotation process. Jigging and tabling were tested but found to be unsatisfactory. Capital costs for tabling were considered to be too high. Dense media separation using a DSM cyclone at a separation density of 3.9 S.G. produced a respectable barite product but a high-pressure operation at the limits of the equipment deterred confidence in using this technique as a commercial process. The most recent gravity method tested was the Reichert spirals and this produced drilling-grade barite with reasonable recoveries.

None of the test programs has been developed to the stage where a plant can be built with sound operating reliability. Further pilot-plant tests are required. A gravity plant using Reichert spirals for barite recovery and flotation to recover the fluorite from the spiral tailings is perhaps the best approach.

5. Scotsville

The Scotsville barite deposit is 3 km southeast of the village of Scotsville in Inverness County, N.S. Access to the property can be gained by two bush roads from Highway 395 which joins the Trans Canada Highway about 30 km to the southeast at the small town of Whycocomagh (Figure 35). The area is rugged and well forested.

(a) Geology The MacInnis barite deposit occurs on the angular unconformity separating the Precambrian George River Group (and minor Devonian intrusives) from the overlying Horton Group of Lower Carboniferous age (Figure 36). These rocks constitute an inlier exposed by local erosion of the crest of north-south trending anticline through this area.



LOCATION MAP OF SCOTSVILLE MINE
SITE & LAKE AINSLIE DEPOSIT

Scale:

1:125,000

FIGURE 35

Date:

9/10/85

Dwn. By:

V.A.H.

Appd:

WA

JACQUES V. WHITFORD
& ASSOC. LTD.

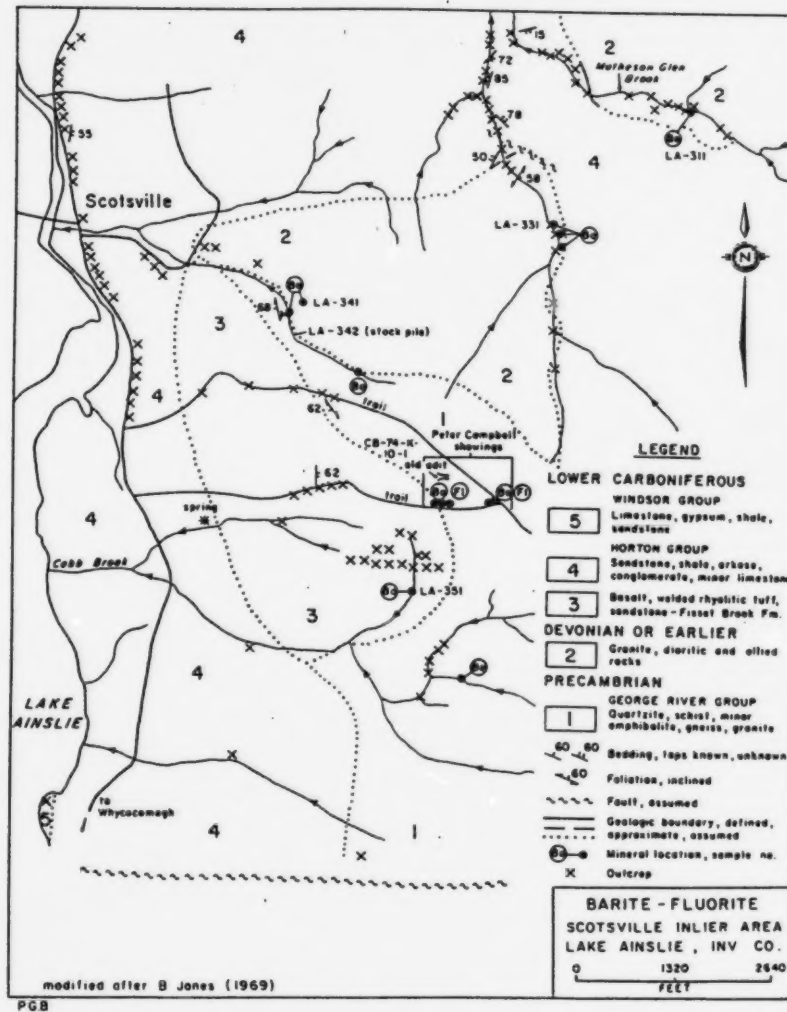


FIGURE 36

NSDME

The highly weathered and altered metamorphic sediments, conglomerate and biotite schist of the George River Group form a paleotopographic high in the area of the barite deposit. The overlying Horton Group rocks consist of conglomerate, sandstone, siltstone, mudstone, minor basalt and a basal breccia derived from the underlying George River Group bedrock. This basal breccia is strongly weathered and altered and is, in part, cemented and replaced with barite. It is this basal unit which is the host for the majority of the MacInnis barite deposit.

Other rocks in the Horton Group include conglomerates composed of angular to sub-rounded fragments up to 10 cm in diameter set in a sand to silt matrix. The sandstones, siltstones and mudstones range in colour from brick red to dark gray and, because they are poorly indurated, readily break into fragments up to 10 cm in diameter. The mudstone characteristically expands and breaks down when exposed to moisture. Fragments of granitic rocks occurring in the basal breccia represent remnant detritus derived from the diorite, granite and aplite intrusions which cut the George River Group basement rocks in Devonian times.

All the sedimentary rocks strike northerly and dip easterly, the Horton Group rocks at 30°, the underlying George River Group rocks steeply to vertical. The Horton Group rocks are cut by numerous faults but they have minimal displacements and seem to have little effect on the barite mineralization.

The mineralization consists of barite, minor (<5%) fluorite and traces of pyrite, chalcopyrite and malachite. The barite is mostly creamy, grayish or brownish white and grayish brown in colour. Some is also gray or reddish brown, the darker colours occurring as a result of iron oxide staining. It is generally medium to coarse grained with the finer grained texture more typical of the darker varieties. Barite occurs as massive aggregates grading >85% BaSO₄, as cement and replacement of wallrock breccia (30 to 80% BaSO₄), as patches and disseminations in the wallrocks (5 to 30% BaSO₄), and as brecciated, medium-coarse grained barite cemented with fine-grained barite, although this is minor. Vugs, about 1 cm in diameter, are characteristic of the barite and may contain petroliferous and carbonaceous material. The fluorite is medium to coarse grained and pale green to greenish blue in colour.

Drilling has indicated that the barite deposit occurs essentially along, and is controlled by, the angular unconformity between the basement George River Group and the overlying Horton Group. It has a thickness ranging between 0.3 and 6.0 m and a length along strike of at least 185 m.

(b) Production Barite was first discovered before 1900 and mined between 1911 and 1916 by open-pit and

underground methods on what has been called the Peter Campbell vein and to a lesser extent on the MacInnis vein. Total production is reported to be from 11,000 to 13,600 tonnes. In the 1970's, A. Hudgins of Truro, N.S. dug some trenches but the results are not available.

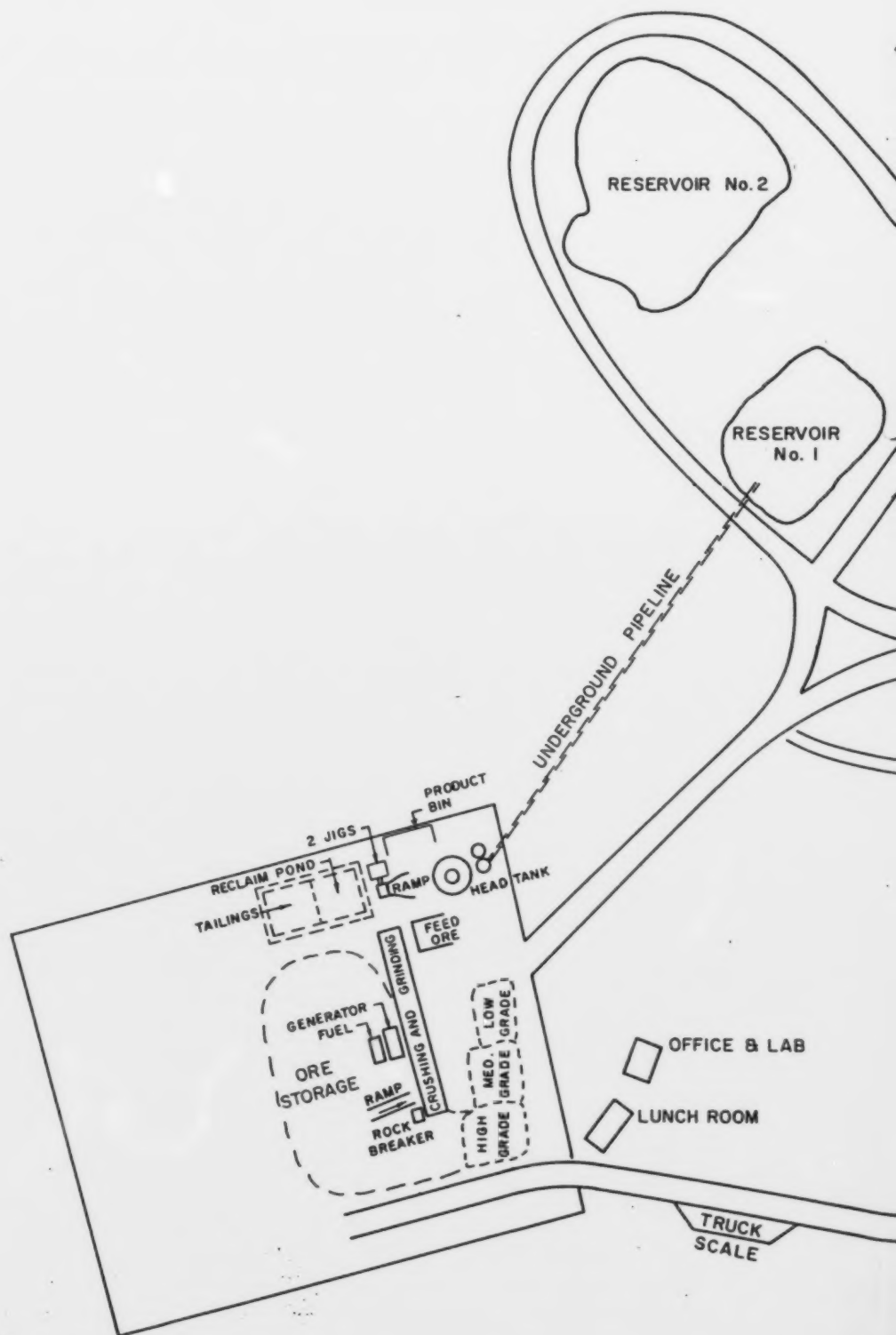
Scotsville Mineral Resources acquired the property in 1980, and in 1982 carried out line cutting, soil sampling, geological mapping, trenching, diamond drilling and a limited VLF survey of the property. In 1983 an 84-tonne bulk sample was analyzed and found to have an average specific gravity of 3.9. The following year, 19 diamond drill holes totalling 613 m in length were drilled and all but two intersected significant barite mineralization. This drilling program has revealed 101,500 tonnes lying above the 45-metre depth. Initial studies by A.C.A. Howe International Ltd. indicated that the deposit could be mined with an open-pit operation (Figures 37, 38, and 39) and jigged to produce drill-grade barite (Figure 40). Preliminary estimates suggest product recovery in the order of 40% of feed at a metallurgical recovery of 70% of contained barite. A jig installation, as discussed in the Addendum, had not attained commercial production at the time of writing of this report.

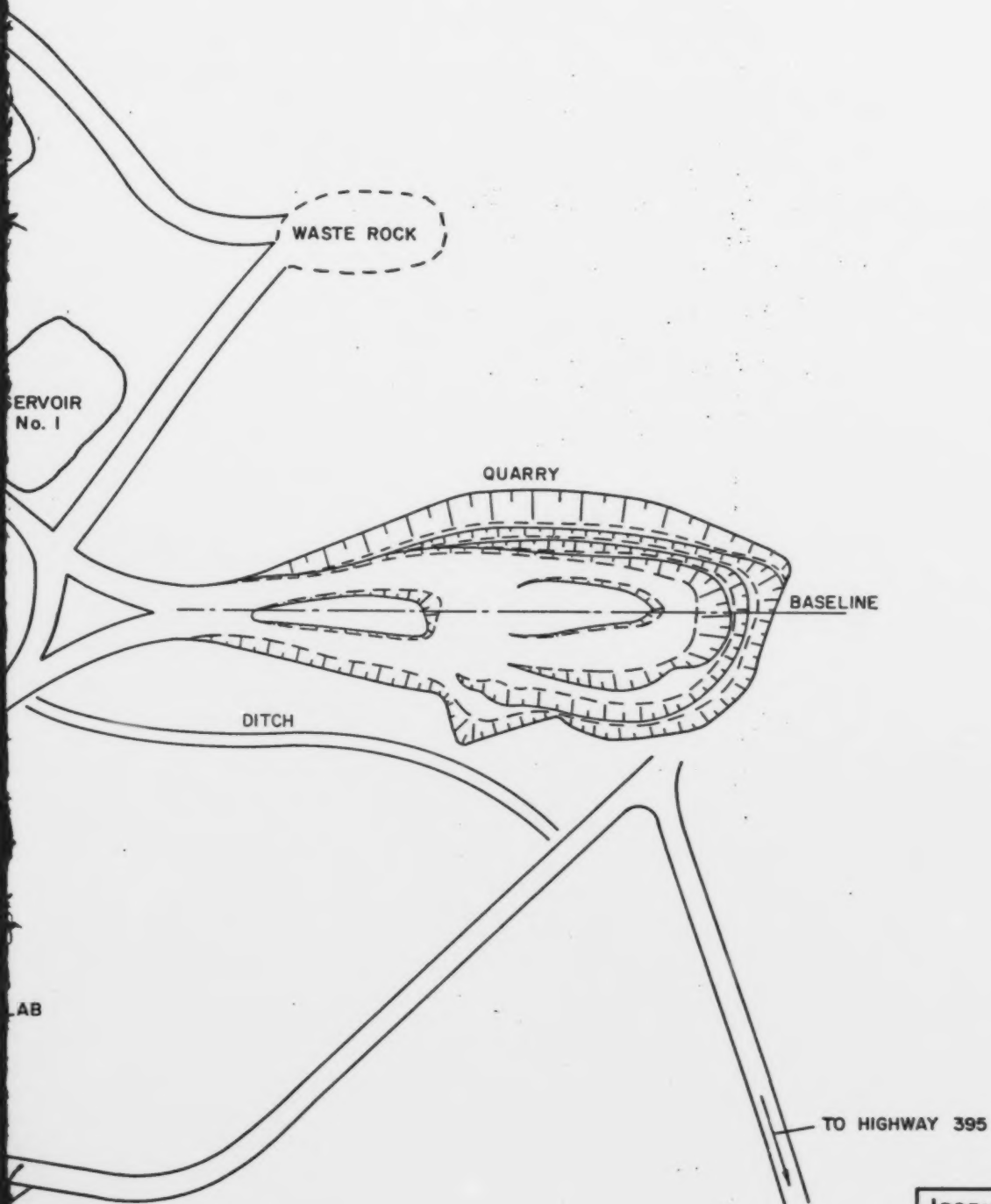
6. Pine Brook

The Pine Brook barite deposit is located on the northeastern side of the Loch Lomond Basin near the hamlet of Lake Vist, Richmond County, southeastern Cape Breton Island (Figure 41). Gravel roads joining Highway 4 at Hay Cove and at Irish Cove, Richmond County and at Big Pond, Cape Breton County provide good access to the property.

(a) Geology The barite deposits at Pine Brook occur in a mixed succession of continental alluvial-fluvial (clastic) and marine evaporite-carbonate sediments of the upper Windsor Group (locally called the marginal basin beds). This lens-shaped series of beds lies unconformably on metamorphic rocks of the Precambrian Fourchu Group and is cut off from the Lower Windsor Group limestones and clastic rocks (locally called the central basin beds) to the southeast by a major northeast-trending fault (Figures 42 and 43).

The barite occurs in a 1-metre bed sandwiched between two, slightly different, pale-green siltstones striking 035° and dipping 10° E. The barite is pale to dark gray, cryptocrystalline, and constitutes between 82 and 86% of the bed. Some of the barite is brecciated, the fragments ranging from 1 to 12 mm, averaging 3 mm. Fine-grained sphalerite and galena cements some of the fragments. Calcite, constituting 12 to 14% of the rock, occurs as fine disseminations in the barite and as relict clumps irregularly distributed in the rock. Opaque minerals, mainly sphalerite,





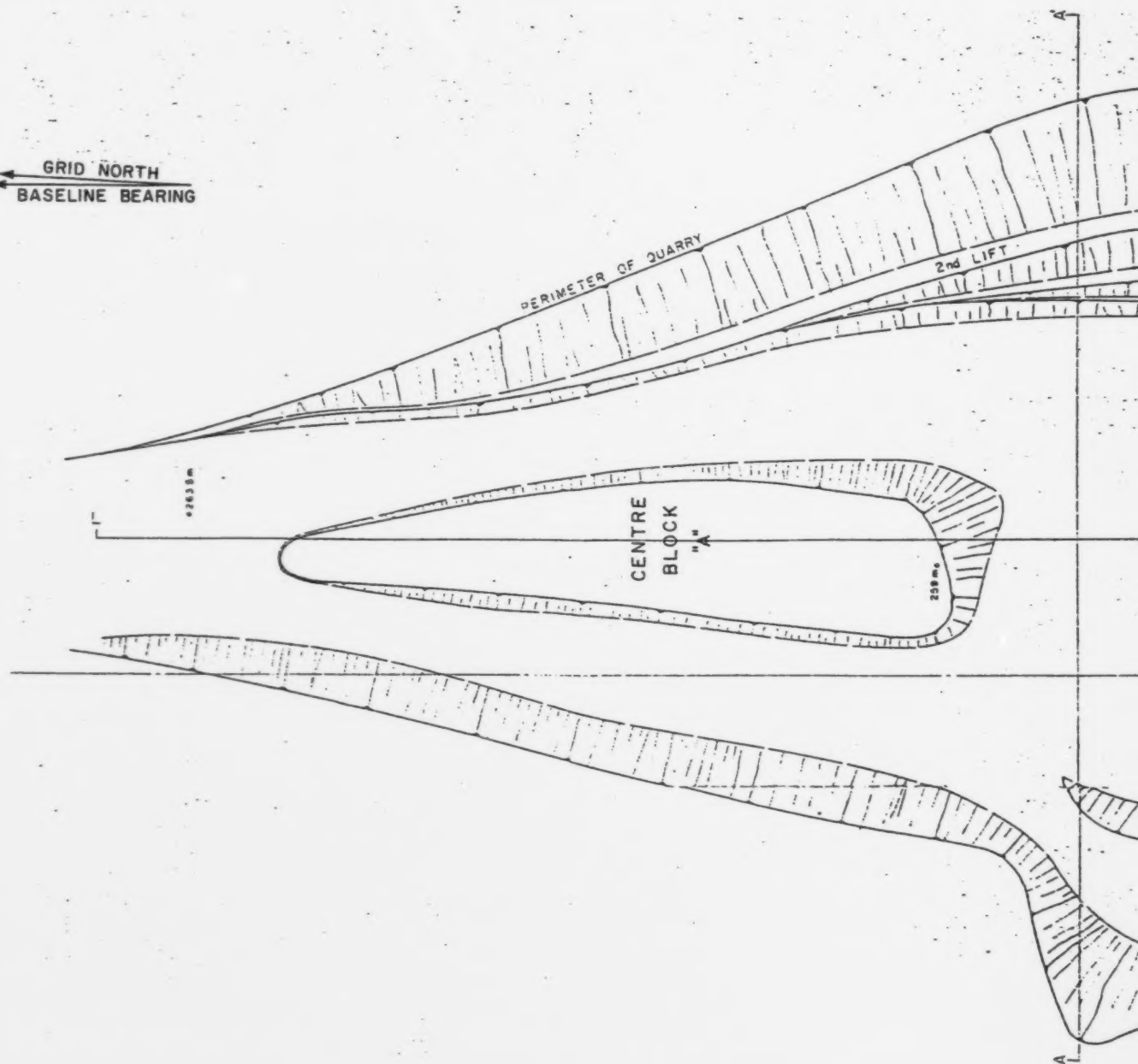
Jacques, Whitford & Assoc. Ltd.

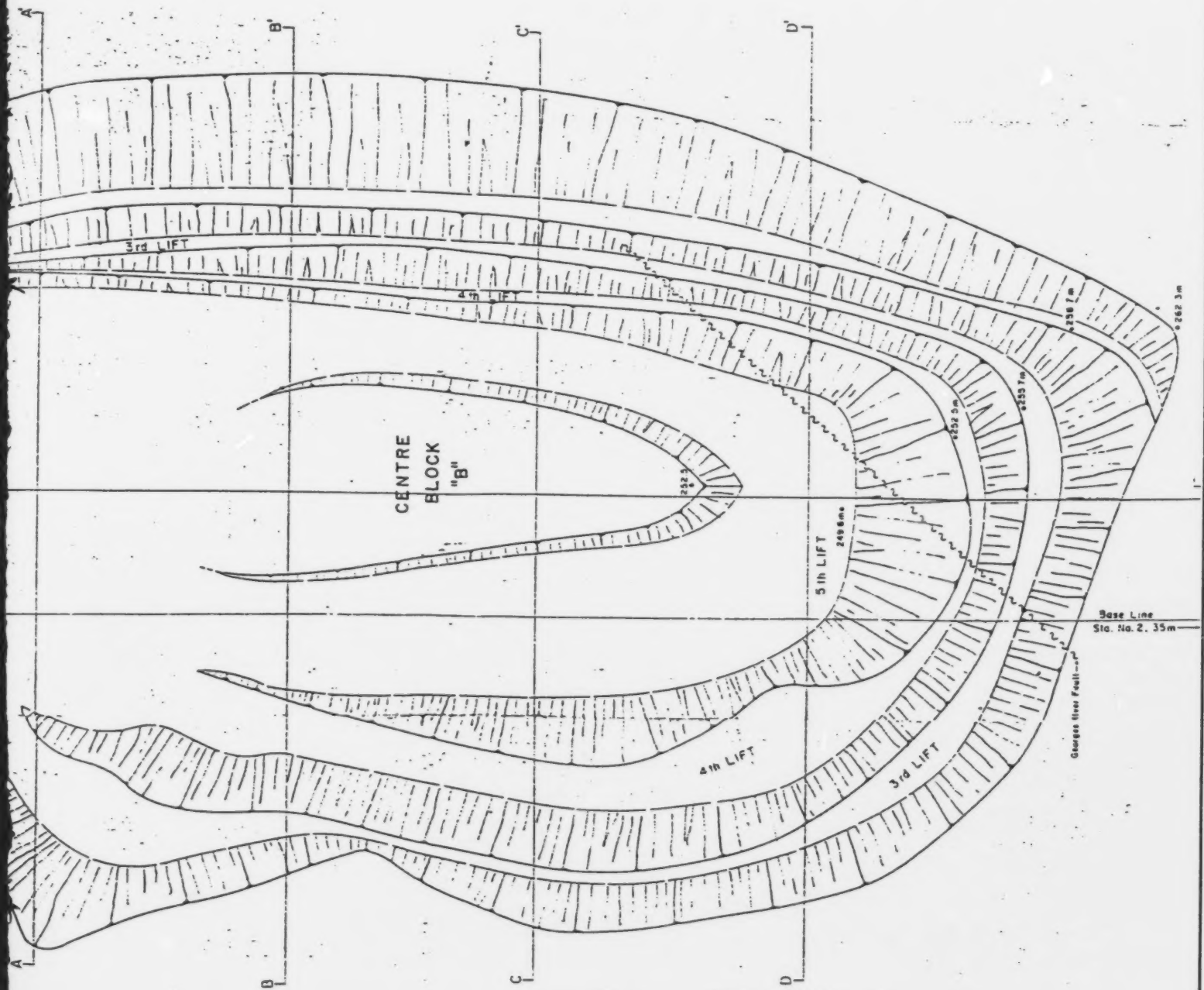
NOVA SCOTIA BARITE STUDY
SCHEMATIC OF SCOTSVILLE

Reference: Scotsville Mineral Resources Ltd. and
N.S. Dept. of Mines & Energy, 1984

Job MI273 8 OCT '85 FIGURE 37

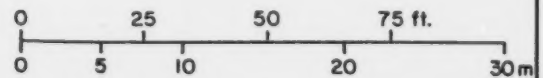
GRID NORTH
BASELINE BEARING





LEGEND :

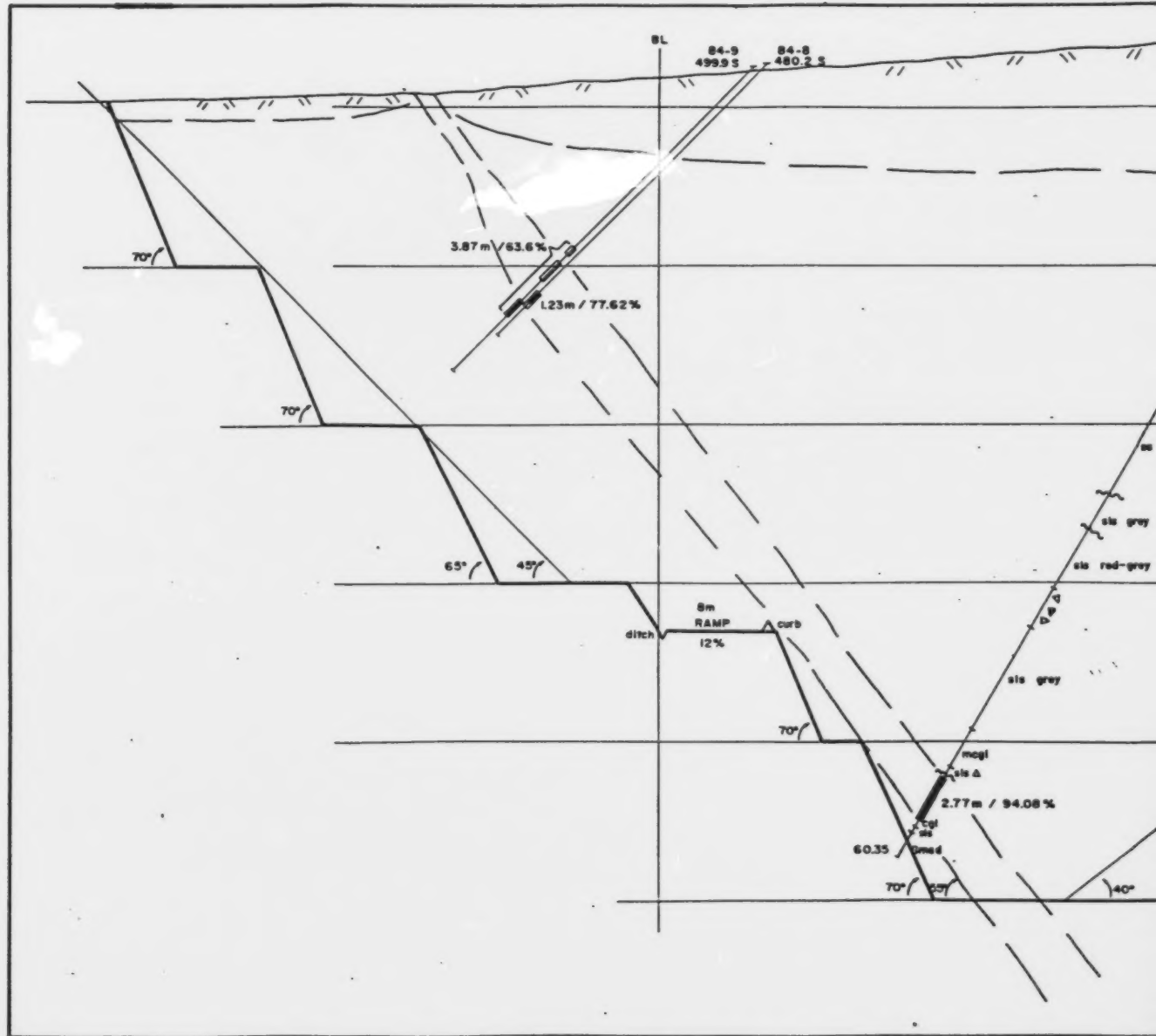
- CREST OF SLOPE
- - - - - TOE OF SLOPE

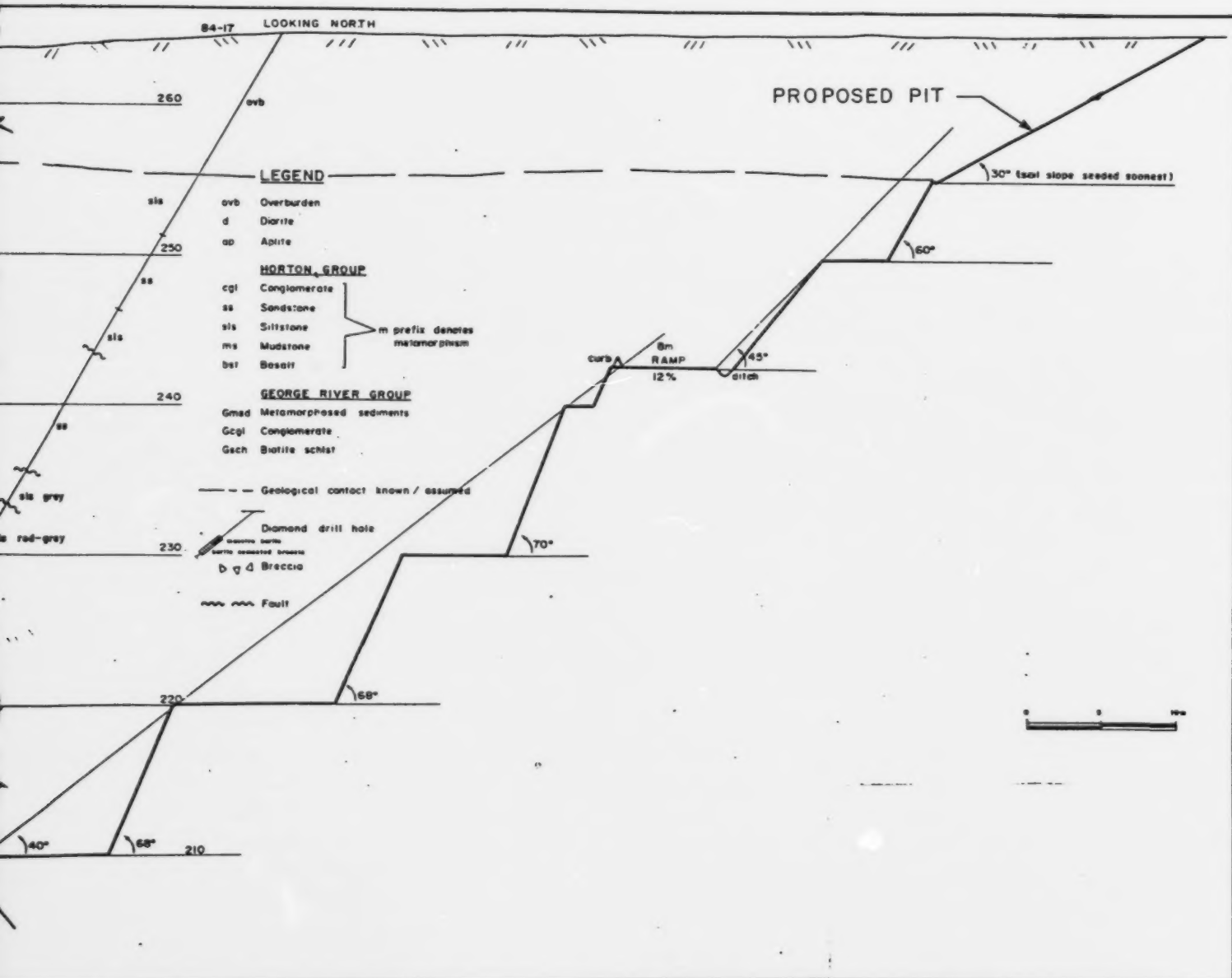


Jacques, Whitford & Assoc. Ltd.
NOVA SCOTIA BARITE STUDY
SCOTSVILLE QUARRY

Reference: Scotsville Mineral Resources Ltd.
1984

Job MI273 '8 OCT '85 FIGURE 38





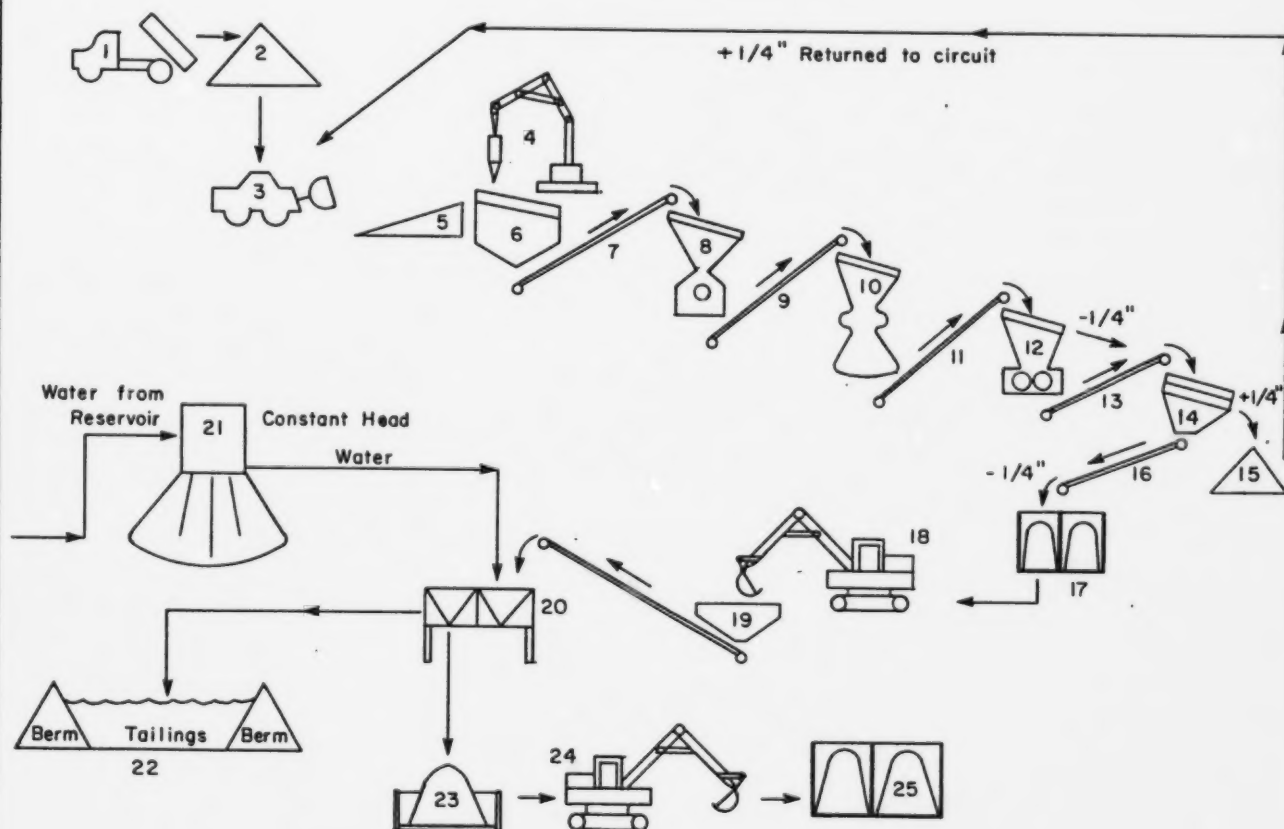
Jacques, Whitford & Assoc. Ltd.

NOVA SCOTIA BARITE STUDY
SCOTSVILLE

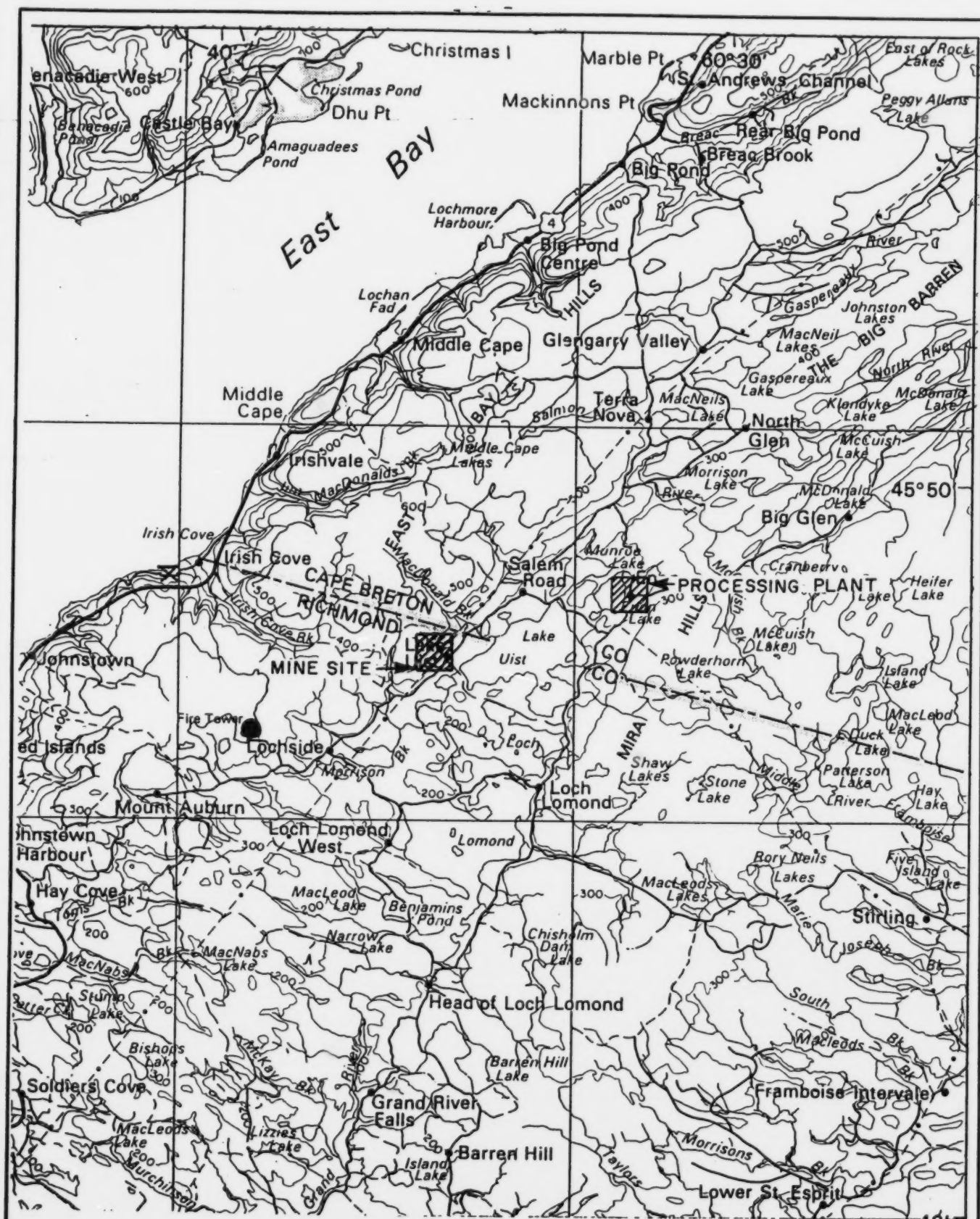
Reference: Scotsville Mineral Resources Ltd.
Feb.-March 1984

Job M1273 8 OCT '85 FIGURE 39

SCOTSVILLE MINERAL RESOURCES BARITE PROCESSING FLOWSHEET



Id. No.	Quantity	Description of Equipment	Size
1		Rear Dump Truck	
2		Run of Mine Ore Stockpile	
3		Front End Loader	
4		Rock Breaker	
5		Ramp	
6		Grizzly and Feed Bin	
7		Conveyor #1	
8		Jaw Crusher	24"x42"
9		Conveyor #2	
10		Cone Crusher	3'
11		Conveyor #3	
12		Fixed Sreen and roll crusher	3'
13		Conveyor #4	
14		Vibrating Screen	
15		Oversize	
16		Conveyor #5	
17		Ore Storage	
18		Backhoe	
19		Feed Bin	
20	2	Denver Duplex Jigs	
21		Constant Head Water Tanks	
22		Tailings Pond	
23		Draining Pad	
24		Backhoe	
25		Finished Product Storage Bin	2x200 t.cap



LOCATION MAP OF
PINE BROOK MINE SITE

Scale:
1:125,000

FIGURE 41

Date:
9/10/85

Own. By:
V.A.H.

Appd:

WA
JACQUES V. WHITFORD
& ASSOC. LTD.

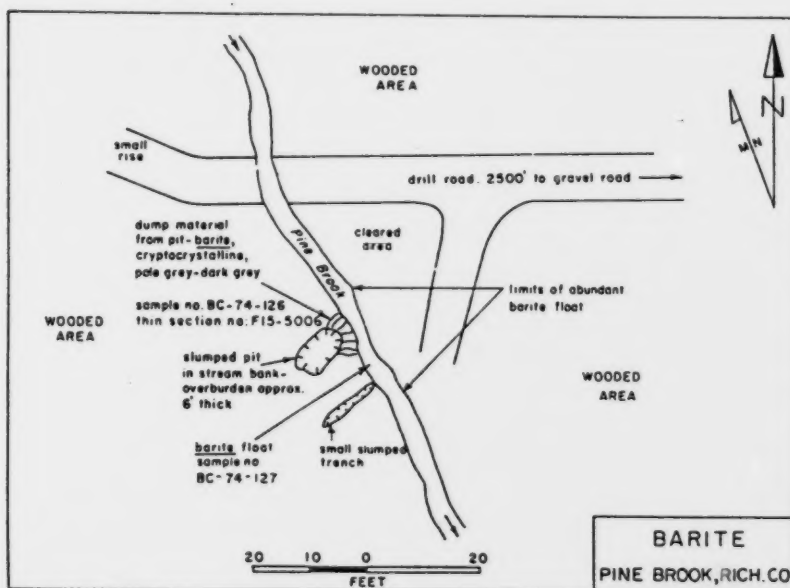
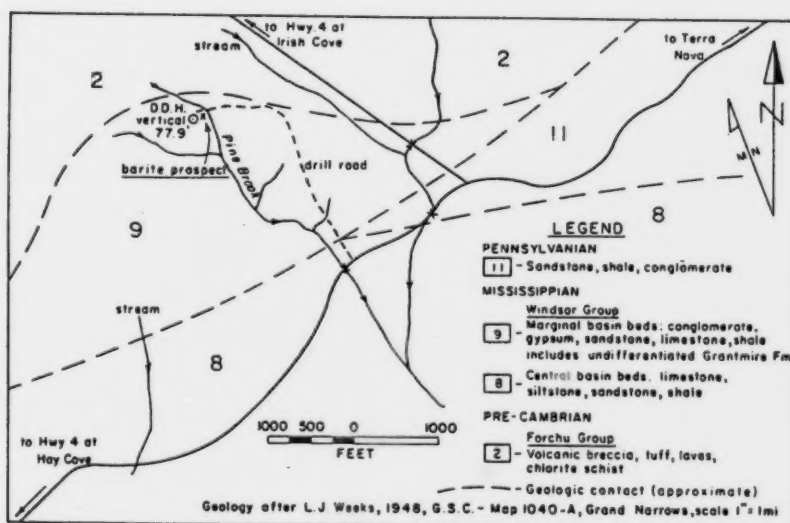
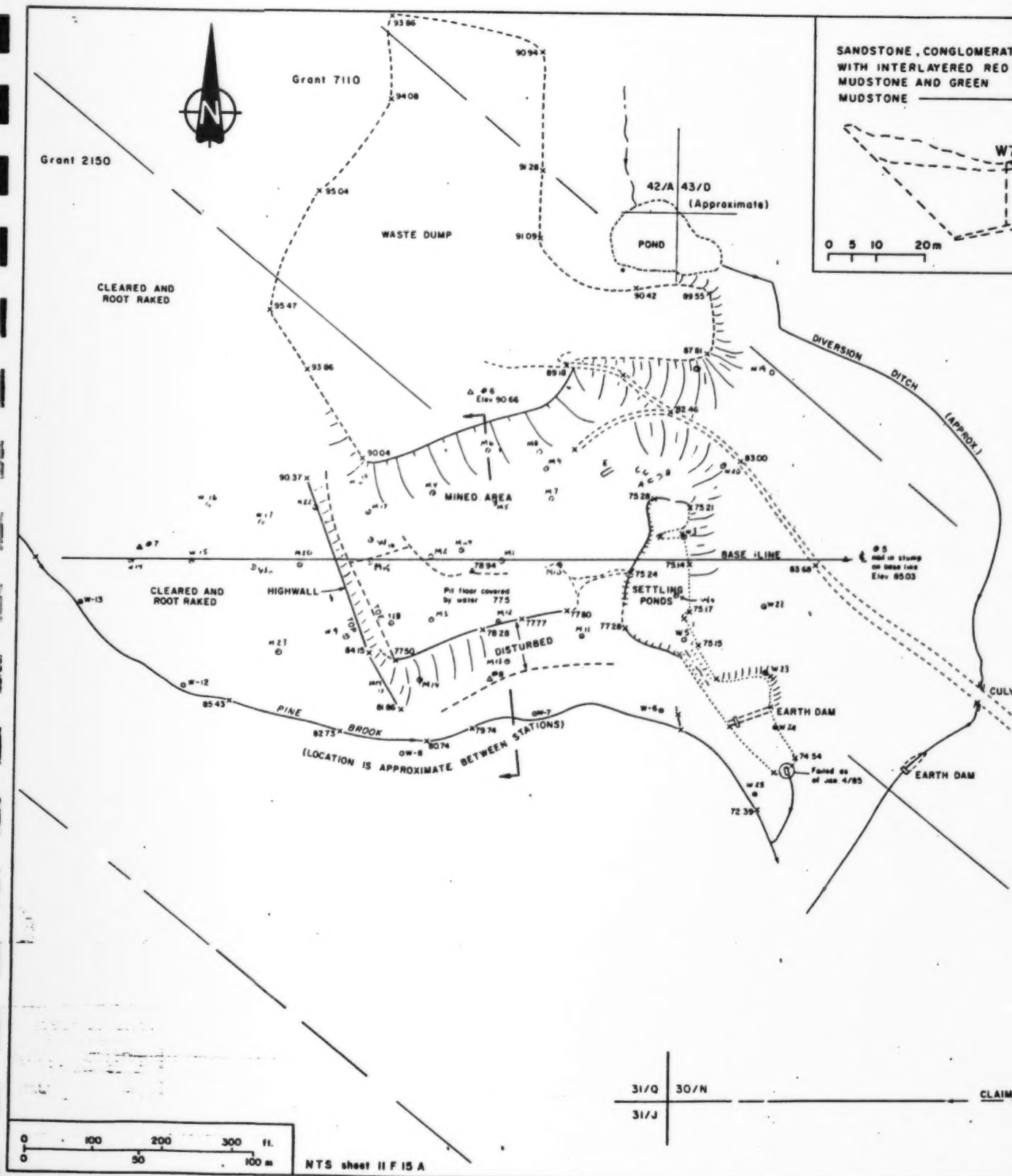
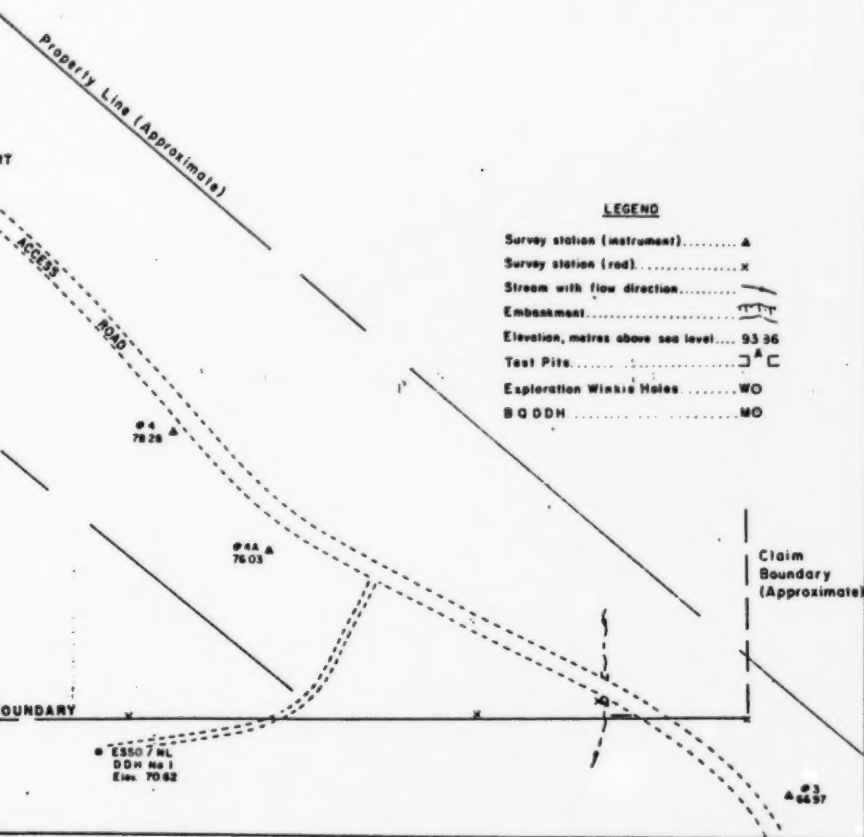
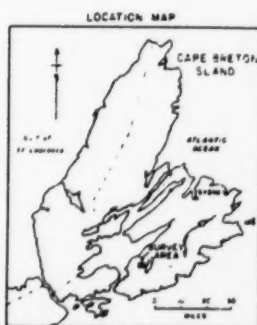
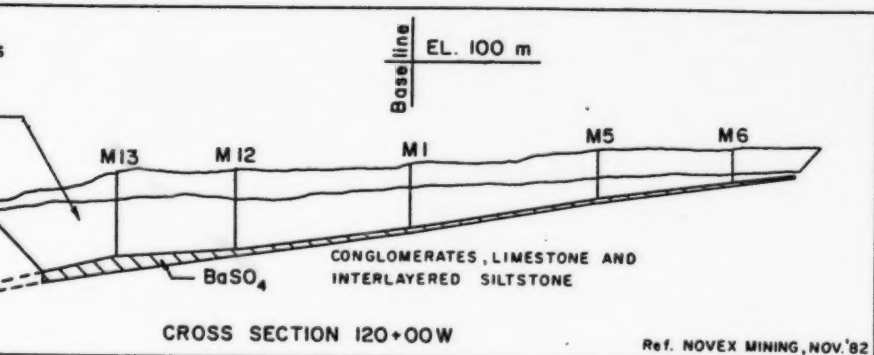


FIGURE 42

NSDME





Jacques, Whitford & Assoc. Ltd.	
NOVA SCOTIA BARITE STUDY	
PINE BROOK	
Reference: N.S. Dept. of Mines & Energy	
26 Nov. '84	
Job M1273 8 OCT '85	FIGURE 43

constitute 1 to 2% of the rock and are primarily found as aggregates of small, spheroidal masses cementing brecciated barite and as fillings of micro-thin cracks. They also occur as sparse disseminations in barite and as minor replacement of calcite and barite.

This barite deposit appears to be stratigraphically controlled, having preferentially replaced a specific bed of the lower Windsor Group. Although the genetic relationship between this deposit and the Kaiser celestite deposit across Lake Enon is uncertain, both deposits have similar physical relationships in that they are hosted by the marginal basin beds which flank a paleotopographic high.

(b) Production Barite at Pine Brook was first mentioned by Hugh Fletcher in the GSC Annual Report for 1876-7. The property was first given attention in 1962 when Lura Corporation Ltd. and Milado Mines Ltd. explored for lead-zinc mineralization by trenching and geochemical and geophysical surveys. One shallow drill hole indicated up to 0.4 m of massive barite. In 1971 Kaiser Celestite Mining Ltd. intersected 1 m of barite in one hole, and in 1978 National Lead/Esso Minerals intersected 0.6 m of barite in another hole 340 m to the southeast. In 1980 Novex Mining and Exploration Co. Ltd. did some drilling and bulk testing. The results encouraged Novex to proceed with open-pit mining and to purchase and convert the dormant Yava celestite flotation mill at Enon to treat barite (Figure 44). Novex reported 80,000 tonnes of mineable barite (70% barite, 30% limestone) of which 12,000 tonnes were treated at their flotation mill and 5700 tonnes sold during 1983 as drilling-grade barite. The operation ceased in late summer of the next year. It is reported that inconsistent product quality and a softening of drill-grade barite markets were factors in the closure of the operation.

The diagram illustrates a continuous casting system for a metal alloy. The process begins with a ladle (12) pouring molten metal into a tundish (15). The metal then flows through a mold (10) and a casting head (1) to form a continuous strand (3). The strand is then guided through a series of rollers (2, 3, 4) and a cooling zone (5) before being coiled into a final product (30). The system includes various components such as a pump (7), a motor (14), a control unit (16), and a cooling system (18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29). The flow direction is indicated by arrows throughout the system.

Id.	Quantity	Description of Equipment	Size
16		Conditioner	
17	2 banks	Flotation cells (rougher & scavenger)	10x50 ft ²
18	2 banks	Flotation cleaners	8x18 ft ²
19		Concentrate Thickener	20 ft.
20		Filter	6'x6'
21		Concentrate Conveyor	
22		Feeder Hopper	
23		Feed Screw	
24		Surge storage	
25		Rotary kiln	
26		Discharge screw	
27		Bucket elevator	
28		Screw	
29		Steel silo	
30		Bagging hoppers	

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VII. APPENDICES

1. Terms of Reference
2. Typical Dense Media Separation System
3. Typical Flotation Flow Sheets For Milling Barite
4. Two Commercial Jigs
5. Specifications For Barite Grades
6. Chemical Analyses of Grab Samples from Some Barite Occurrences, N.S.

APPENDIX 1

DSS File No.: 07SQ.23440-5-9059

NOVA SCOTIA BARITE STUDY - DEPOSITS, DEVELOPMENT, MARKETS

STATEMENT OF WORK

BACKGROUND

Barite (barium sulphate) has a number of uses, chief of which are as a heavy additive (weighing agent) in drill mud mixes; in pharmaceutical formulations for use in X-ray examinations of the throat, stomach and intestinal tract; and as a filler mineral in plastics, paint, rubber and sealing compounds.

Nova Scotia has a number of developed or potentially developable barite deposits including those at Lake Ainslie and Loch Lomond in Cape Breton, and at Brookfield and Walton (tailings) in mainland Nova Scotia. There is interest by a number of companies in developing or further developing these deposits to provide barite for the above-noted uses (markets) but there, unfortunately, are a number of associated problems including ore delineation and quantity, ore quality and complexity of mineralogy, beneficiation procedures, market specifications and delineation of markets, and market competition, both current and potential, from both domestic and foreign sources of barite.

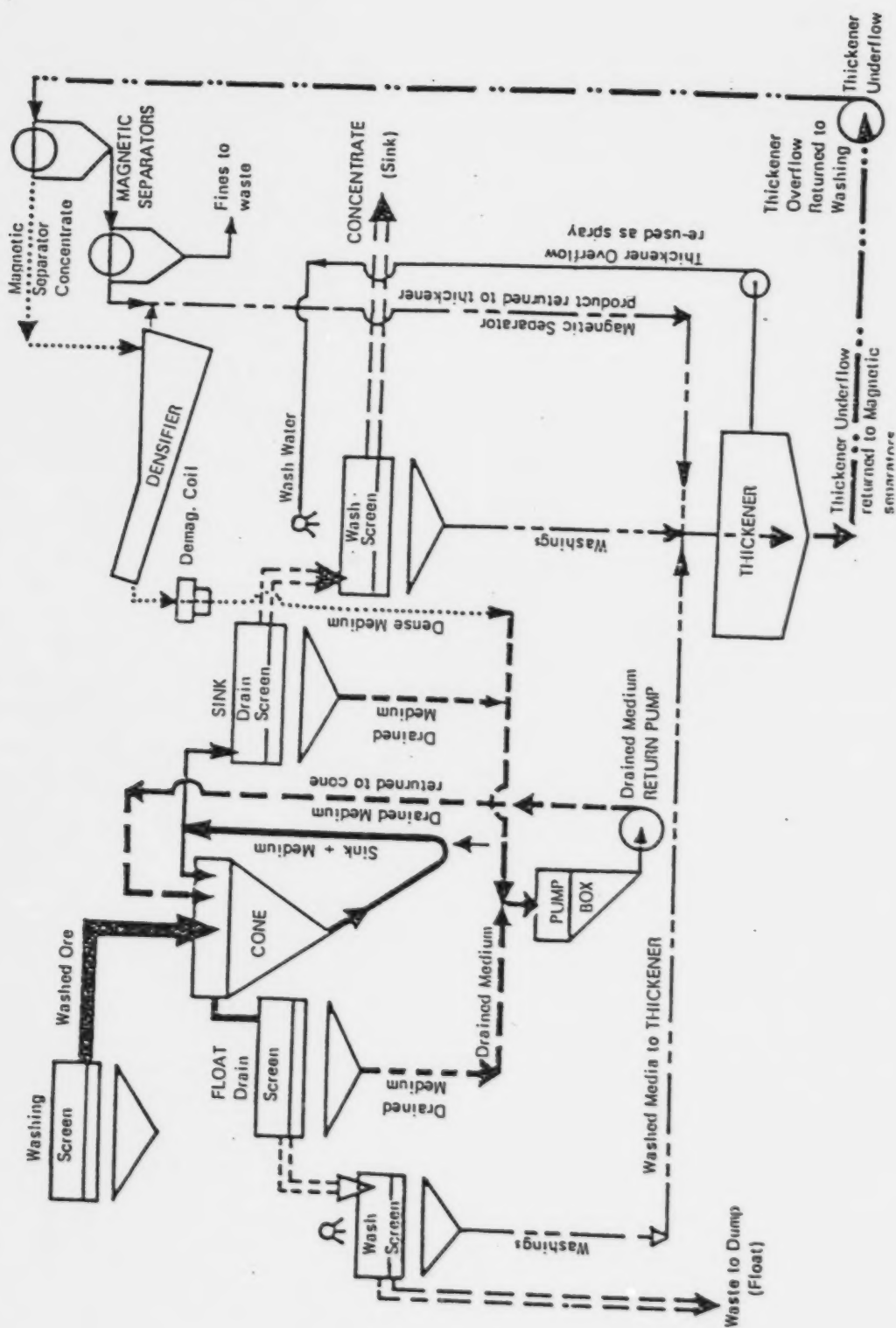
The off-shore market (Atlantic region) for mud-grade barite is currently estimated at 20,000 to 30,000 tpa. This market undoubtedly will grow with increased off-shore oil-well drilling activity both from the standpoint of the number and depth of holes. Imported barite, chiefly from Ireland and Morocco, along with limited domestic production is supplied to this market via "drill-mud agencies" of which there are several in Nova Scotia. The fuller participation by Nova Scotia producers or potential producers in this market should be encouraged and supported.

The current identified market (Atlantic region) for pharmaceutical grade barite is only about 1500 tpa, although there is good potential for growth. The size of the current and potential market for barite as a filler in plastics, paint, rubber and sealants is unknown but these are growing and developing markets; barite, for example, is gaining acceptance as a "tracer" in plastic toys to aid detection of these toys or bits thereof by X-ray following ingestion by children.

There is need, as it were, to "sort out" the current situation vis-a-vis producers/potential producers, deposits, reserves, mineralogy associations, processing and beneficiation problems and procedures, market specifications, market size and competition, and the potential for market participation by domestic producers.

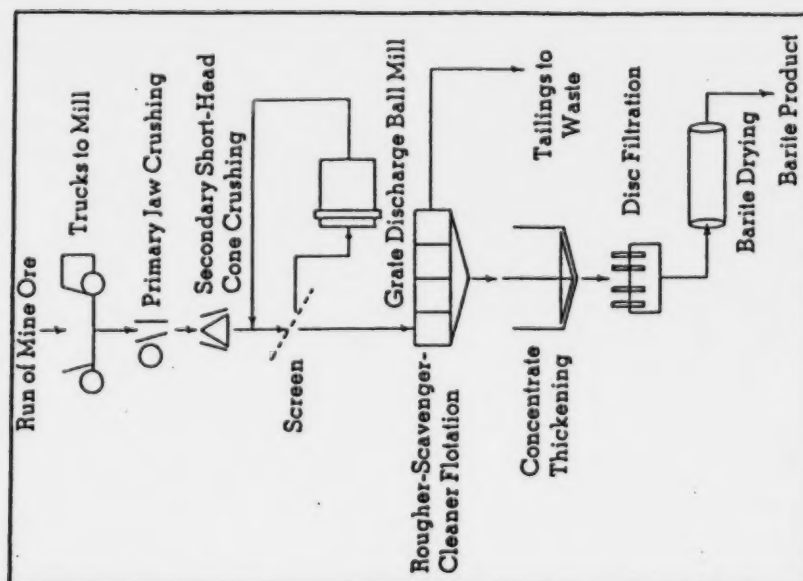
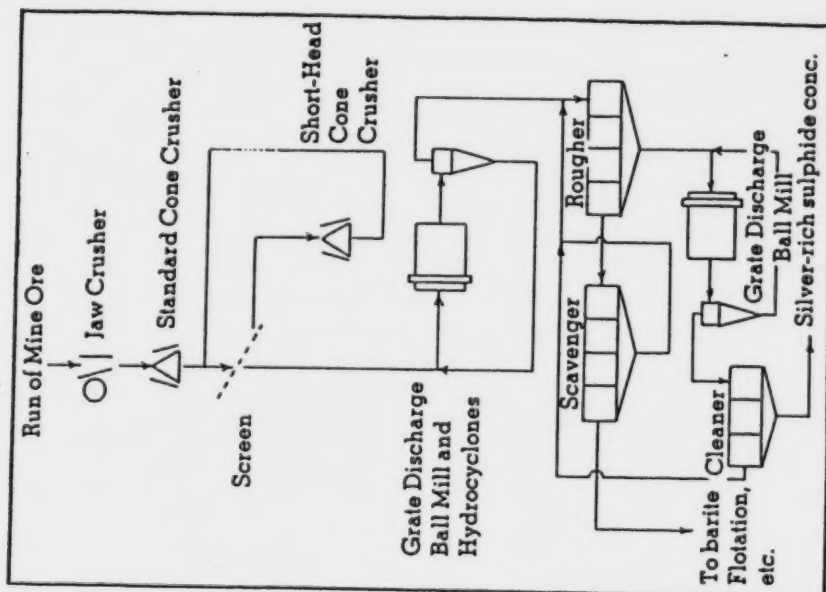
OBJECTIVE

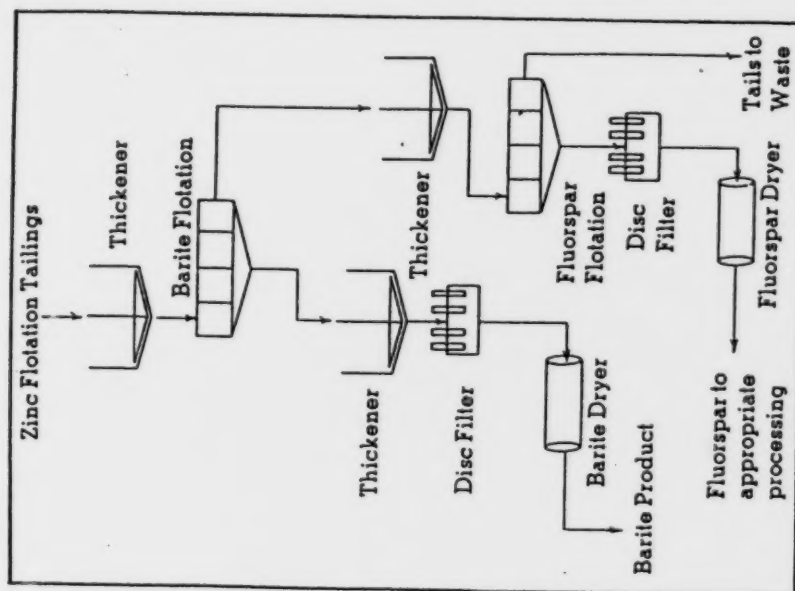
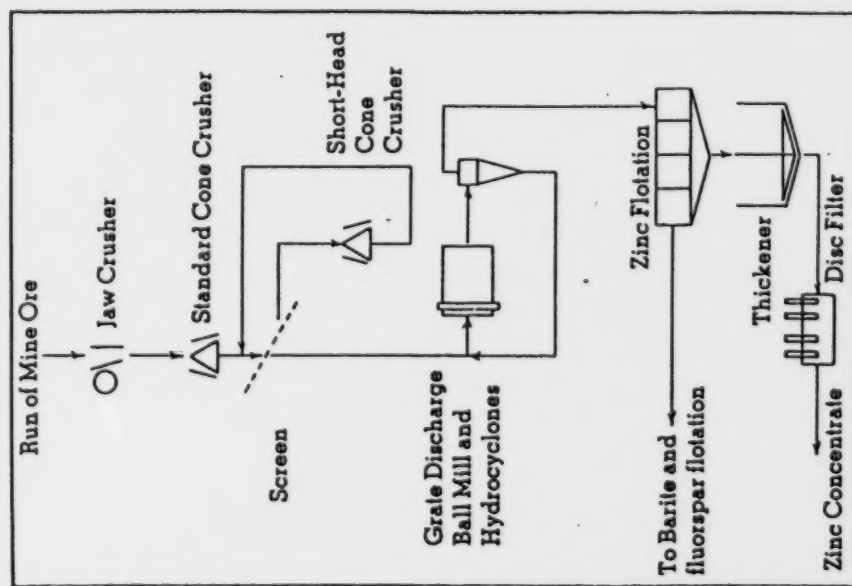
To make a detailed study and report of Nova Scotia barite encompassing deposits, required beneficiation procedures, activities of producers/would-be producers, market situation, and ability of Nova Scotia producers to gain entry into these markets and to compete with other sources of barite including Morocco and Ireland.

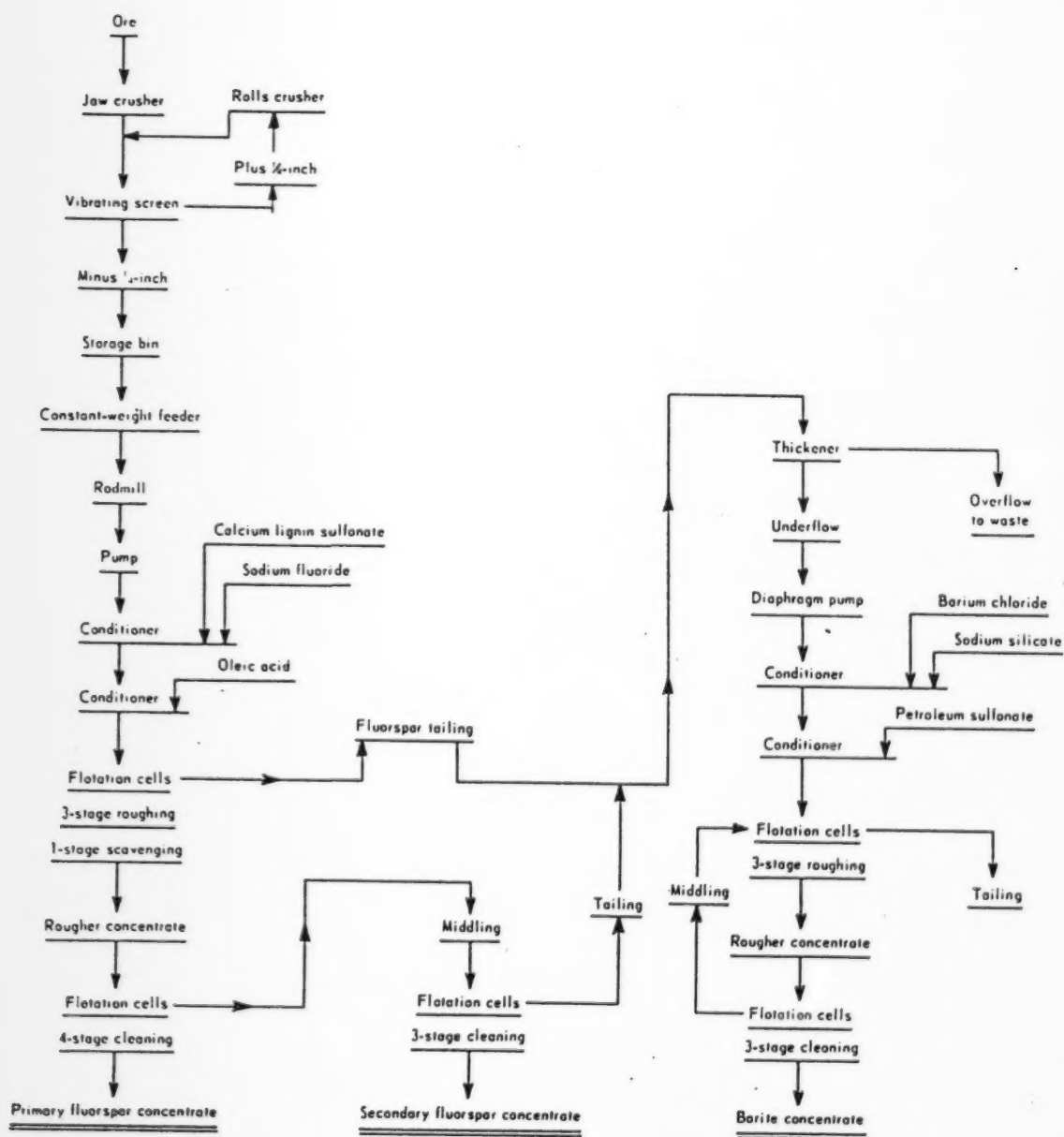


APPENDIX 2: Typical Dense Media Separation System

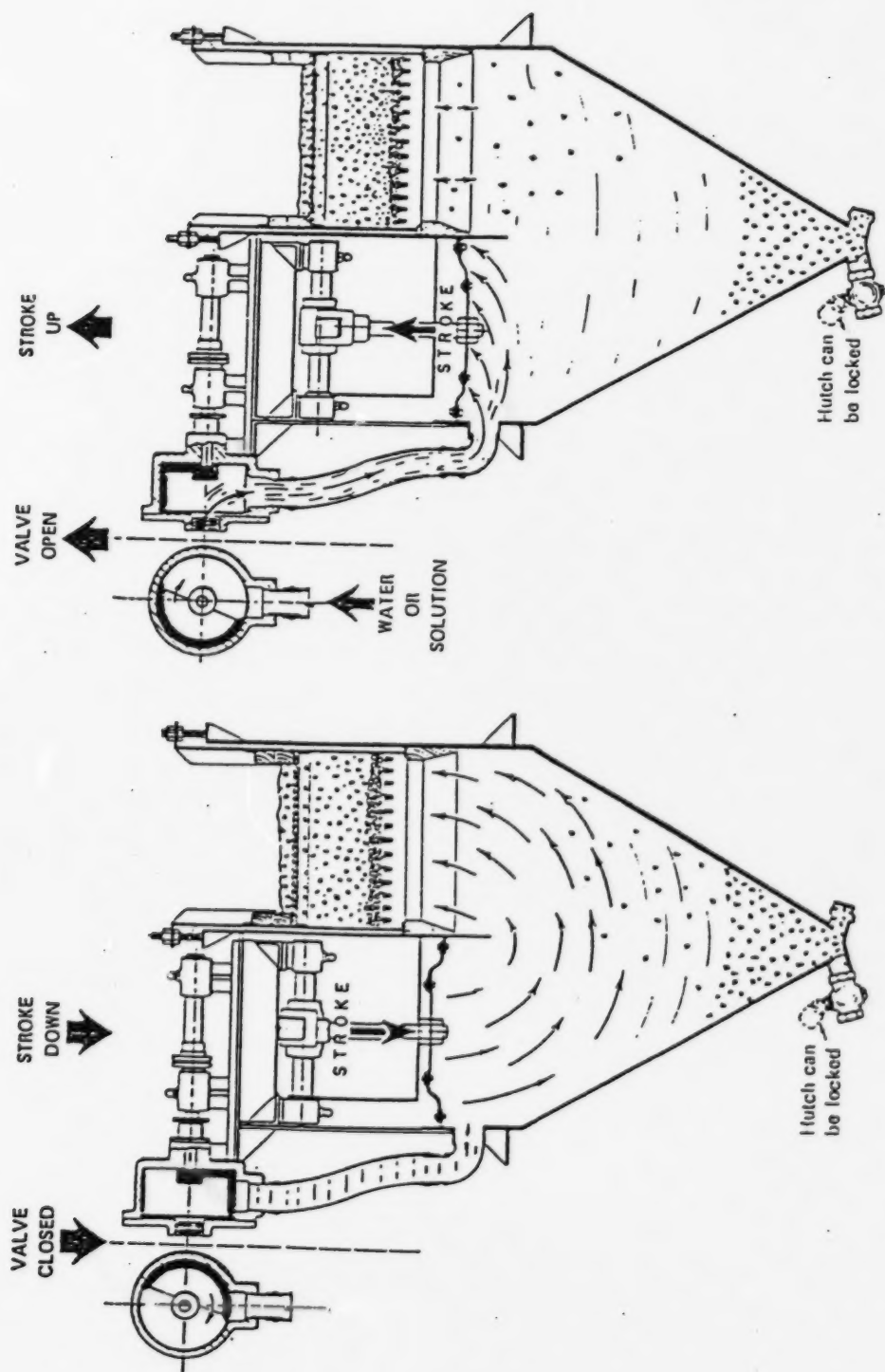
APPENDIX 3: Typical Flotation Flow Sheets for Milling Barite







APPENDIX 3: - Flowsheet, Recovery of Fluorspar and Barite From Tennessee Ore.



APPENDIX 4: — THE DENVER MINERAL JIG
Courtesy Denver Equipment Company, Denver Colo.

THE BENDELARI DIAPHRAGM JIG

This jig is the invention of F. N. Bendelari, President of Consolidated Lead & Zinc Company and is a product of the Tri-State Lead & Zinc Field where gravity separation has been practiced for over forty years. Many types of jig have been used in this Field but in recent years the so called "Joplin type" of Cooley jig alone has survived. The Bendelari diaphragm jig was designed as an improvement on jigs of that type.

The principal characteristic of the Bendelari jig is the use of diaphragms instead of plungers to cause pulsations. The lineshaft and eccentrics are below the hutches. A tube through each hutch to the plate which carries the diaphragm permits of connecting the eccentric by means of wrist pin and crosshead with the diaphragm head without using a stuffing box. The plate which carries the diaphragm is octagonal in shape, which leaves the corners open and permits mineral to pass from the pulsion chamber into the still water in the hutch.

In the earlier models of this jig the diaphragm head was rigidly connected to the eccentric and had an oscillating motion similar to the diaphragm in a diaphragm pump. As now constructed with wrist pin and crosshead the movement of the diaphragm head is vertical, a longer stroke is possible and the weight of the diaphragm head is carried on the crosshead instead of being thrown against the rubber. The rubber diaphragm now acts as a seal only.

The advantages claimed for the diaphragm jig are,—Efficiency, as there is an even action over the whole bed and because of unusually favorable conditions for settling fine mineral in the still water in the hutch. Compactness, with savings in floor space and cost of foundations.

Durability, being ruggedly constructed of $\frac{3}{8}$ " steel plates, double electric welded and heavily reinforced. Safety, as the lineshaft and eccentrics are housed under the hutches. Convenience, as the operator of a battery of jigs can walk from one to another over the top. Convenient too, because the design is so compact that jigs can be delivered through mill doors and moved through mill aisles.

The action of the diaphragm produces positive pressure as compared to the momentum given to the water by a loose fitting plunger and the bed is lifted with less pulsion. For the same reason stronger suction is available if required.

A feature of these jigs is the control valves. Water from a manifold is admitted below the sieves through check valves on the downstroke of each diaphragm. The amount of water so admitted is regulated by the control valve on each cell. The action of the jig can be changed while running by manipulating these valves.

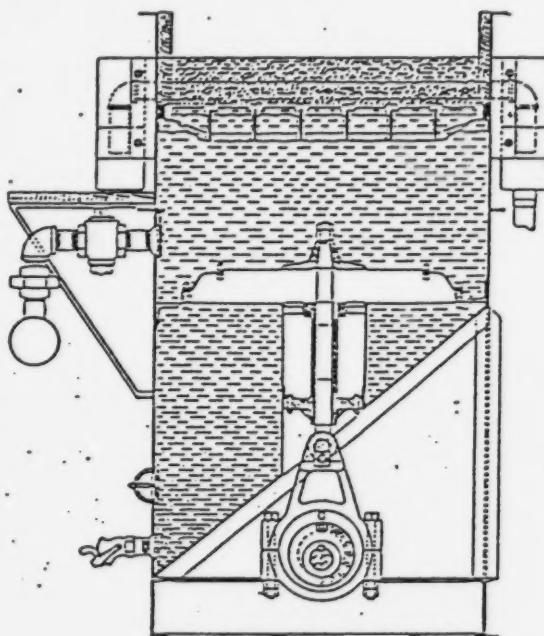
The sieve frames are of novel design. The webs are streamlined and touch the sieve cloths only at intersections of the webs where the sieve cloths are supported and fastened. Practically the whole sieve area is effective. Provision is made for lifting sieve frames without damaging sieve cloths.

Stratification is very rapid on these jigs. Different "draws" are used for different minerals. The fact that mineral can be drawn from both sides of the beds is a great advantage.

Capacity depends on relative gravity of mineral and gangue, size of feed and nature of the ore treated.

Power requirement varies with speed, length of stroke and amount of suction used. The latter being the most important factor.

Provision is made for wear. Eccentrics have metal shims. The crosshead guides have renewable brass bushings.



BENDELARI DIAPHRAGM JIG

APPENDIX 5
Specifications

1. Drilling-grade barite

Specific Gravity	4.20 minimum
Soluble Alkaline Earth Metals as Calcium	250 ppm, max.
Wet Screen Analysis	
Residue on US Sieve #200	3.0%, max.
Residue on US Sieve #325	5.0%, min.

Ref.: American Petroleum Institute Specification 13A for Oil-Well Drilling-Fluid Materials, 1981.

2. Chemical-grade barite

Barium Sulphate content (lump)	92-96% min.
Barium Sulphate content (floated)	96-98% min.
Strontium Sulphate content	2% max.
Calcium fluoride	0.5% max.

Ref.: Industrial Minerals, Dec. 1982.

3. Typical Blanc Fixe Paper-coating Grade

Density	4.0-4.2
Brightness	95-99
Mean particle size (microns)	0.5-4.0
Specific surface (sq. metre/g)	4.0-4.5
Hardness	3-4
Binder requirement	
(g casein/100g pigment)	9-14
Oil index (g oil/100g pigment)	12-22
Water index (g water/100g pigment)	16-23
Zeta potential (mv)	-20 to -35

Ref.: Industrial Minerals, June 1984.

APPENDIX 6

CHEMICAL ANALYSES OF GRAB SAMPLES
SOME BARITE OCCURRENCES, N.S.

<u>Location</u>	<u>Sample No.</u>	<u>BaSO₄</u>	<u>SrSO₄</u>	<u>F</u>	<u>Cu</u>	<u>Pb</u>	<u>Zn</u>
Brookfield	BC-74-69	64.10	1.02	.03	10	10	10
	BC-74-70	71.20	0.93	.03	16	70	14
	BC-74-71	89.75	1.23	.03	10	13	14
	BC-74-72	93.00	1.22	.03	7	7	7
Bass River	BC-74-134	65.70	1.42	.03	20	50	10
	BC-74-135	97.00	1.92	.03	20	50	10
	BC-74-135	92.85	1.13	.03	40	40	50
Lake Ainslie	CB-74-K-1	93.05	0.57	2.94	20	10	20
	CB-74-K-2	95.60	2.10	.90	80	10	20
	CB-74-K-3	76.13	1.80	10.80	110	10	20
	CB-74-K-4	80.67	1.60	5.40	160	30	20
	CB-74-K-5	91.50	2.20	1.60	80	10	15
	CB-74-K-6	42.25	1.41	18.32	80	30	30
	CB-74-K-7	92.05	2.08	2.50	40	10	50
	CB-74-K-8	73.92	2.19	12.20	80	30	30
	CB-74-K-9	96.60	2.48	0.37	10	10	20
Scotsville	CB-74-K-10	94.73	2.62	1.30	10	10	20
Pine Brook	BC-74-126	93.30	2.20	0.08	180	100	5030
	BC-74-127	96.30	2.33	0.04	90	60	1030

Source: NSDME, Bull. No. 4, 1978.

All values in ppm except BaSO₄ and SrSO₄ in per cent.

IX. ADDENDUM

MAGSTONE DEVELOPMENT INC.

UNIT No. 5 • DEBERT AIR INDUSTRIAL PARK • PHONE (902) 662-3222
P. O. BOX 89 • DEBERT, NOVA SCOTIA • B0M 1G0 • TELEX 019-34587

NOTES
ON VISIT TO
SCOTSVILLE MINERAL RESOURCES LTD
WEEK OF SEPT 9, 1985

Magstone Development Inc.,

W. J. D. Stone, P.Eng

President

To, Mr. R Collins

CC Mr. P. Hannon

Mr. R. MacDonald

Mr. R. Stewart Patterson

Mr J Amirault

Introduction:-

Magstone Development was requested to make Stone available to visit with Scotsville Minerals. Arrangements were made in co-operation with Jacques Whitford and Associates for the time of Stone for approximately 1 week. The object was to assess the 'jig plant' situation and to determine the necessary steps to bring the 'jigs' to successful production and to implement such steps as far as time and facilities and the ability of Scotsville to effect such implimentations.

The contract specifically did not require a written report. However, these notes will hopefully be helpful.

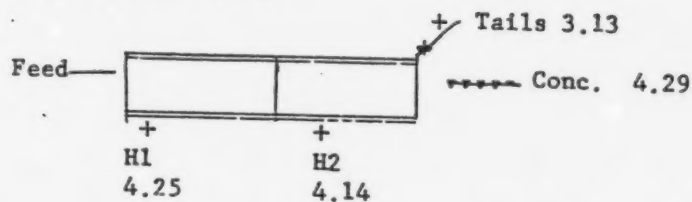
Summary.

1. Both jigs have been run continuously and simultaneously to produce apparent acceptable product..
2. Until implementation of equipment for feed control hutch discharge and concentrate removal can be installed these problems can be overcome by extra manpower.
3. There is no reason why the jig operation, i.e. loading feed bin to stockpiling concentrate cannot be run with a 2 person crew. Of course, this is after the implementation of additional controls etc.
4. By 'short-cut' S.G's and visual inspection, the jig product looks very good with excellent tailings. Bye 'eye' the tailings contain less than 5% barite - maybe less than 2%.
5. Initial bulk sample in a 1 hour run on one jig indicates a plant capacity of over 100 tons per day of concentrate on a 24 hour running basis. This needs to be confirmed with several days running.
6. There is no reason why this jig plant; with relatively minor additions cannot produce good product on a continuous basis with a 2 man crew.

S. G. Results

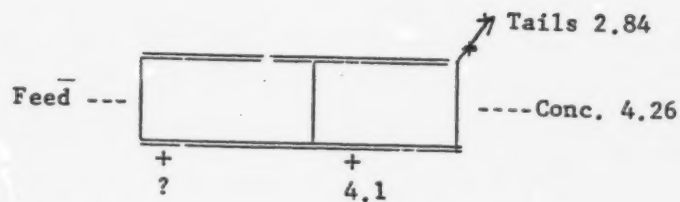
Jig Number 2

Sample set 1 S.G.'s

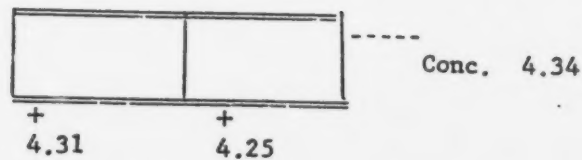


Jig Number 2

Sample Set 2



Jig Number 1



At time of leaving Scotsville the above S.G-s only were available. However there is no doubt that overall grade was being acheived.

Major Problems and Solutions

1. Clearance of Concentrate

At the moment there is no adequate system to remove concentrate. One man shovelling could not keep up with the discharge. One solution would be a screw conveyor/classifier that could handle all concentrate products.

2. Hutch Discharge

The current system requires that the hutch^s be drained by the intermittent opening of valves by hand. This results in jig performance disturbance by either drawing excess off the hutch or by the excess building up in hutch.

There are automatic discharge valves for hutchs which operate when a certain height of solids have been achieved in the Hutch. Denver

Equipment should be contacted.

Production Rate

Small samples were taken but in their context establishment of a production rate was not possible.

However, on Thurs, Sept 12 the production from Jig No. 1 was collected in a truck for 1 hour. Big difference, the collected wet rate was 3.3 metric tons in 1 hour. Allowing 20% moisture content, this gives 2.64 metric tons per hour per jig. This was much higher than what I expected but was a pleasant surprise. Such a rate would give the plant a capacity of over 100 tons per day. More rate determinations will be required to establish confirmation.

The jigs should produce by fine tuning a further 50%.

Jigs Initial Comments

1. The Jigs are not the best type for Barite
2. The adjustment mechanism for control of the cell product leaves much to be desired.
3. For practical purposes a system for the continuous discharge of the hutch products does not exist. The valve system currently implemented is difficult to operate. However, until a better system can be installed it can be made to work with suitable operator application.
4. The lack of easy controls on the jigs make the control more dependent on the feed rate control.
5. The water flow over the bed is excessive in velocity, The appearance of the bed was not acceptable.
6. After considerable experimentation with different height weirs on the tailings discharge, a 2" weir was adopted, but only temporarily. In addition a make shift baffle was installed between hutch no 1 and 2. The end result was a bed where the water was quiet and good product was made. There is no way to set out this technically by paper instruction. By onsite adjustment, combination of working variables were achieved. The result of perfecting them would result in substantial increase in production rate.
7. A change of feed rate quickly results in a change of quality of product. If the feed rate ^{decreases} ~~drops~~, Hutch No. 2 becomes 'dirty'. The jig operator has to have facilities to combat such changes. They can be either
 - a) quick change in feed rate
 - b) The normal readily adjusting of height of cell control; not available on the current jigs. The jigs are missing a very important control facility. This is due to inherent design and not due to operators. The situation could probably be rectified.